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HYDROGRAPHY.

HYDROGRAPHY (from the two Greek words, *ὕδωρ*, *water*, and *γράφω*, *description*, is the important branch of physical science and descriptive geography which has for its object the graphical representation of the waters of our globe and their shores, with all their properties bearing upon navigation.

Their exploration to this end, their description by means of charts and directions for the use of the navigator, as also the generalization of the local data in order to ascertain the laws governing the physical phenomena upon which navigation depends, the winds, currents, weather, tides, terrestrial magnetism, etc., is the responsible and arduous task of the nautical surveyor and hydrographer.

The most essential requirement for navigation is charts, general charts of entire oceans, or parts of them and their shores, compiled by the hydrographer from existing data, and special charts of smaller areas, of harbors, roadsteads, etc., prepared from special surveys. The earliest sea-charts date from the middle of the fourteenth century. They were necessarily rude and imperfect, the earth's shape and dimensions being then unknown, the log for measuring nautical miles not in use, and the means for ascertaining astronomical positions very imperfect.

The discovery of America and the Cape of Good Hope, together with the reformation in astronomy by Copernicus and Galileo, instituted a new era in geographical knowledge; the earlier charts of this period, however, were still grossly inaccurate, especially as regards geographical positions, and many of the isolated islands of the Pacific Ocean, seen and described by the early Spanish voyagers, have been searched for at later periods in vain, until islands in positions differing hundreds of miles from those given to them, but answering their description completely, have been adopted for them; many of

the islands shown on the present charts with queries, in regions not yet sufficiently explored, will prove to have been similarly misplaced at that early date.

The science of hydrography, by which the correct establishment of positions and exact delineations of the shores are attained, remained meagre until the middle of the eighteenth century, when it may be said to have fairly commenced with the expeditions of Captain James Cook under the auspices of Great Britain, which were soon followed by similar undertakings by other nations, especially by France and Russia, and at a later period by the United States. Almost all these voyages of discovery and explorations were of circumnavigation, and, though many localities were examined more or less in detail, in general they could only result in skeleton charts to be filled in by systematic surveys, at a future period, conducted under the direction of organized institutions. In the first quarter of the present century hydrographic offices were established by the principal maritime nations for the survey of their waters at home and in their colonies. To the hydrographic office of Great Britain, which has been liberally provided with means by the Government, belongs the credit of having taken the lead in extending systematic surveys into almost every water traversed by vessels, and to its zeal and energy all navigators and commercial communities will ever be deeply indebted. At present almost every nation having a seaboard has it hydrographic office for the survey of its own coast, and to participate in the survey of such waters as are considered the common possession of nations, and of the coasts of countries which do not provide for surveys. Almost every European nation has provided for the trigonometrical survey of its entire domain.

The British Ordnance Survey, commenced in 1783, will probably take ten years yet to complete; the trigonometrical surveys of France, Germany, the Netherlands, Belgium, and the European portion of Russia, are in course of completion; in other countries they are in progress. The several governments have also agreed on measures for the careful connection of the triangulations across the borders of their states. Where such rigid geodetic operations were instituted previous to the hydrographic survey of the coasts and waters, they furnish the hydrographic surveyor, not only with the correct outlines of the coast, but also with the precise position of the landmarks upon which he may base his work, or, in other words, a skeleton for the same. But, when such surveys are not existing, he is compelled to lay down the coast-line also, with its detail as far inland as there are landmarks auxiliary to navigation, thus performing the labors of the topographer as well as those of the hydrographer. Both require the greatest care, for on the precise establishment of the landmarks depend in a great measure the delineation of the shoreline, the establishment of outlying dangers, and the exact location of

the soundings, by which the profile of the bottom is represented on the chart.

Sudden elevations, shoals, and especially submerged rocks, the great dangers to navigation, sometimes escape the lead as well as the eye, even in the most careful survey, and are only discovered by accident, often from disaster. Such dangers are found from time to time in the most frequented harbors, which have been surveyed with the greatest care. While the land, with the present means, can be laid down absolutely correct, the hydrographic surveyor can never be certain that he has thus represented the most essential portion of his chart.

The hydrographic features of coasts, not rock-bound, are subject to changes, gradual by the action of the sea, and sudden by natural phenomena, as great gales, etc.; volcanic activity also affects at times the rock-bound coasts. The mouths of rivers and the embouchures of inland waters are especially subject to changes by the wash of the discharging waters, and the sediment and *débris* carried along by them, which mostly accumulate on the bars, and are shifted to and fro by the force of the sea before they settle firmly; the depth of water in the channels, and even the course of the latter, does not remain the same for any great length of time, and some bars change with every shift of the wind. The surveys of such localities will only hold good in their general features; in the shore-lines and in the landmarks by which a vessel may approach and feel her way in; the more frequented harbors of this nature require reëxamination from time to time.

Several nations have provided for a trigonometrical survey of their coasts only, in advance of geodetical operations embracing their entire domain.

The United States Coast Survey was first organized by act of Congress in 1807, which provided for surveying the coasts of the United States, but the first labors in this field did not commence until 1817, and were shortly after interrupted; in 1832 they were resumed, and have since been carried on, with energy and but little interruption, to the present date.

The United States Hydrographic Office, for the purpose of constructing and publishing charts, sailing directions, and all hydrographic information relating to the coasts and waters outside of the boundaries of the United States, for the use of its marine, both naval and commercial, and for directing the examination and survey of the channels of commerce in foreign waters, was established under the Navy Department in 1866.

Connected trigonometrical surveys have also been instituted for the waters of the more important of the European colonies, especially in the West and East India waters and in Australia, but for far the greater part of the navigated portions of the globe the navigator will for a long time have nothing but reconnoissances and running surveys,

of which the earlier are more or less rough and unconnected, and even some of later dates cannot be entirely relied upon.

Running surveys, more or less in detail, are generally the precursors of the more strict geodetic survey, but, in order to answer the wants of navigation, these should always be based upon a triangulation between natural landmarks, checked at reasonable distances by very careful shore observations for latitude and longitude, and the latter carried directly from a central position to the most prominent points of the thus surveyed area and back again, and the central position connected in the same manner with the nearest satisfactorily determined position, to which the longitudes of that locality are generally referred.

The telegraph-cables which already connect many of the most important places will soon gird the globe in several belts, and will afford the means for ascertaining great meridional distances with almost absolute correctness. There will thus be furnished a great number of primary positions from which the longitude may be carried in coördinate lines to secondary places. In this manner a network of points spread over the globe will be attained, corresponding to the primary and second triangle points of great geodetical operations.

The completeness and correctness of a running survey depend upon the time devoted to it and the difficulties encountered; frequently the coast-line is only traced in from point to point, or from the shore-ends of the lines of soundings by the eye; the points of land, however, especially the salient ones, should always be fixed by angles to or from the established landmarks, as should also all outlying dangers and all features bearing directly upon or assisting navigation.

The surveys of harbors and anchorages should be as complete as possible; if time permits, beacons should be erected for triangulation, and the plane-table employed for obtaining the shore-line. The parts of the latter which are merely traced in approximately should be distinguished on the chart by a broken line.

The soundings should always be numerous enough to show the configuration of the bottom of harbors, and off a seacoast the gradual rise from great depths to the shore, islands, and banks, so that the characteristic curves of the depths may be shown with precision on the charts; for harbors generally the one, two, three, and five fathom curves are marked; on coast-charts, those of three, five, ten, twenty, fifty, and one hundred fathoms.

When sounding from a vessel in motion or from a boat, the lead should be tried at intervals, even when it is anticipated that the bottom will not be reached, not only on account of the possibility of the discovery of a sudden elevation, but for the purpose of placing the negative soundings on the chart, which show conclusively the absence of danger and that the ground has been examined.

For such negative soundings, as much line should be used as the

speed of the vessel will permit, and at reasonable distances the deep-sea lead should be employed to obtain actual depths. Positive soundings exceeding 100 fathoms should be obtained as far to seaward as circumstances will permit the survey to be extended.

A difficult task of the hydrographic surveyor is, to search for the islands and dangers shown on the charts, or enumerated in nautical guides as uncertain in position or of doubtful existence.

Many facts show that the origin of a great number of these may be traced to deceptive appearances, to misplacement from faulty observations or reckoning, or to typographical errors in the reports published.

Reports of new dangers grow more frequent, as the sea-routes extend into regions heretofore but little traversed, and as the commercial navigator manifests a greater interest in hydrography. All these obstructions to navigation are placed on the charts, usually with queries, until they are verified and correctly located, or their non-existence proved by professional authority through local search. Such dangers have frequently been found to exist at considerable distance from the positions given, from indifferent astronomical observations, or from reckoning referred to observations taken several days before or after their discovery; the search must, therefore, be extended over a considerable area. The search for islands is naturally less difficult than that for submerged dangers, which on the broad ocean can in some instances hardly be detected but by chance.

In causing reported dangers of this nature to be erased from the charts, on the strength of a search which has not been thorough in every particular, the hydrographer incurs a grave responsibility; there are a number of instances on record where dangers which had been searched for most carefully and by very competent authority, have been replaced exactly in the position from which they were erased, after they have been assured by the loss of a vessel on them, and the reëxamination of the position in consequence of it.

A correct representation of the character of the bottom of the waters is very important, not only for the selection of anchorages, but also as a guide to the navigator when he cannot otherwise obtain the position of his vessel, especially when approaching a coast in fogs and thick weather, or when passing through channels not bordered by good landmarks; for this purpose specimens of the bottom should be brought up for examination, and every change of it noted.

The tidal relations, tidal hour, and the rise and fall at the various stages of the moon, and in the various seasons, the influence of the winds upon the tides, etc., can be deduced accurately only by observations continued through a longer period than the limited time of a running survey will generally permit. Observers should, if possible, be left for this purpose at the important points. A lunation is the shortest period in which approximate data can be arrived at, but ob-

servations for a shorter time, and by rough means, may prove of some value, and such should be made daily.

Meteorological observations, the direction and force of the winds, the appearance of the sky and clouds, temperature, the pressure and humidity of the atmosphere, etc., should be made at the stations occupied for tidal observations; they can then be made with more precision than those usually made on board ship.

Every opportunity should be availed of for gathering information from intelligent residents in regard to the local, tidal, and meteorological relations, in order to complete deficient observations. Permanent currents are correctly ascertained in places where a vessel can anchor, by various methods of observation, on the deep sea generally by the difference between the position by observation and that by the dead-reckoning.

The active hydrographic surveyor will not, while on the ocean, neglect to aid in the labor of the physicist, by examining into the condition of the water, its temperature at the surface and at various depths, its specific gravity and salimity, its fauna and flora, and by contributing to the natural sciences, general geography, geology, and ethnology, while in regions which may be not at all, or but little, explored.

The hydrographic part of the information thus obtained is laid down for the use of the navigator in charts and text-books in such a manner as to be rendered complete without interfering with clearness and ready comprehension.

Charts must contain with distinctness every feature upon which the navigator relies, coast-line, outlying dangers, peaks of mountains, with their height, conspicuous objects, etc. Sea-charts are constructed for publication on Mercator's projection, although this projection distorts the relative size of the several areas and the bearings of points; the more so the farther the chart is extended toward the poles. Navigators, however, prefer it to the more correct conic projections, as it represents the meridians and parallels of latitude in straight lines, thereby facilitating the laying down positions and bearings. The careful hydrographer will plot his work on a conic projection, and thence transfer it to that of the Mercator. The gnomonic projection—projecting areas on a plane tangent to the earth from the earth's centre—represents the great circles, the shortest distances between two points by straight lines, and in this has advantages for charts of entire oceans. As yet, this projection has not been used to any extent. All conspicuous objects on which the navigator depends should be given preference in distinctness of delineation over that of mere detail.

Upon the intricacy of the configuration, especially that of dangerous passages, will depend the scale to be adopted, which should not be so large as to render the chart unhandy, and not so small as to interfere with clearness. Usually the work is first laid down on a scale

large enough to show at a glance any fault in the projection, and then reduced to the scale decided on for publication. On the latter, objects of importance, especially dangers to navigation, should be exaggerated in preference to their not being sufficiently conspicuous. The soundings obtained, especially in harbors, will be far too numerous to represent them all, even upon the working-sheet; care must be taken in selecting the characteristic soundings, which must be reduced to a certain state of the tide, usually to low water, and they must be placed on the exact spot representing that in which they were obtained. Heretofore these were expressed in the standard measure of the country in which the chart was published, but recently the French metre has been adopted by all maritime nations, excepting Great Britain and the United States, who use the English fathom and foot. It is preferable to use on the same chart but one unit, either fathoms or feet, as the use of both, even with the shading, frequently leads to error. In order to show better the structure of the bottom, and to make irregularities more conspicuous, curves of equal depths—fathom-curves—are laid down. The denomination of the curves depends upon the depth of water that can be carried into the harbor or along the coast. Harbor charts generally show the five, three, two, and one fathom curves, the latter three often distinguished by shades of sanding (dots to represent sand); the five-fathom curve is expressed by rows of five dots on the line of the curve. Coast-charts generally show in addition a ten, fifty, and one-hundred fathom curve.

The character of the bottom is represented by the first letter, or an abbreviation of the word, expressing it; currents by arrows, with the force in knots per hour or per day placed along them; buoys and beacons are shown by conventional signs.

Lines of bearing point out the courses to be steered, and guide also in avoiding dangers. Views, placed so as not to interfere with the sailing-ground, show the appearance of the land on the bearings on which they are taken.

An important feature of the chart is the compass, placed in such positions as are most convenient for taking off the courses. On harbors and special coast-charts the compass-points are generally laid off from the magnetic north line; on general ocean-charts, on which the variation changes rapidly with the lateral distances from the direction of the magnetic curves, they are laid off from the true north.

General charts, and frequently harbor-charts, have the projection drawn over them, from which the latitude and longitude of any point represented on it can be ascertained minutely; where the projection is not thus drawn, the astronomical position of a well-defined point is given, usually under the title, with the mention of the primary position to which it has been referred. The title also embraces the tidal hour, with rise and fall of tide, at the full and change; the unit of measure in which soundings and elevations are expressed; the scale

on which the chart has been constructed, and an explanation of the conventional signs used on it; these latter, however, are generally supposed to be known.

General notes regarding the winds, currents, tides, harbor facilities, etc., are frequently added, as also sometimes sailing-directions; but generally these are left for text-books, which, under the titles of "Directions," "Memoirs," "Manuals," or "Pilots," give to the navigator the information obtained by the hydrographer, with the general results arrived at, which cannot be engrossed on charts.

By a judicious arrangement and a complete index, these should be made as intelligible and as ready for reference as possible, and should contain all the points within the area treated on that are of interest to navigation.

The first treatise on marine surveying, published in a practical form, was by Alexander Dalrymple, in 1771. This was followed by the work of M. Beautemps Beaupré, in 1808; since which time there have been published many valuable works on marine surveying, adapted both to running surveys and to greater geodetical operations.

In hydrographic surveys and exploration, England has always been foremost. Her Hydrographic Office, dating from 1795, under Alexander Dalrymple, was not firmly established until 1828, when Captain Francis Beaufort became the hydrographer to the British Admiralty; since which time, under the administration of the line of distinguished navy officers his successors, it has steadily advanced, to the inestimable benefit of commerce, both British and foreign. At the present date the charts of this office number two thousand nine hundred and eighteen, and yet about one-half of the coasts and navigable waters of the world remain unsurveyed, a great part not even examined.

An interesting skeleton chart of the world, compiled at the British Hydrographic Office and attached to a paper delivered by Commander Hull, R. N., superintendent of the Admiralty charts, before the Royal United Service Institution, showed the portions of the coasts of the world surveyed, partially surveyed, and only explored.. Taking this continent alone, between the parallels of 60° north and 60° south, beyond which whaling-vessels only generally go, it will be found by rough measurement that about 12,000 miles of the seacoast have been surveyed, 20,000 miles partially surveyed, and that 8,000 have been only explored. Coasts partially surveyed or only explored require the utmost caution for safe navigation; and, even with this, vessels are constantly in peril. For the remainder of the globe, with exception of Europe, the proportion of the inadequately-surveyed and almost unknown coasts and waters is much greater. This should demonstrate clearly the vast field of labor awaiting the maritime surveyor.

England perseveres in this work, and her hydrographic parties are found in every quarter of the globe, opening new channels to commerce, and defining the dangers of navigation. France, in her publi-

cations issuing from her Department des Cartes et Plans, is hardly behind Great Britain; from the time of the father of French hydrography, M. Beautemps Beaupré, to that of its present distinguished director, Vice-Admiral Jurien de la Gravière, this office has not ceased to assert its prominence and usefulness. France, however, though constantly and systematically prosecuting foreign hydrographic surveys, has not carried this work to the same extent as England. Spain, of late years, has rested on her laurels of the past, and with other maritime nations, with exception of casual foreign surveys, has restricted herself to the shores of her own possessions, and to issuing from time to time valuable publications and information for the benefit of navigation. The United States Hydrographic Office, though yet in its infancy, has made rapid progress, and now issues a respectable number of publications; no permanent system, however, of hydrographic surveys has ever been successfully instituted under the Navy Department. On its own coast, in its waters and harbors, the work of the United States Coast Survey is extensive, scientific, and thorough, and many years will yet be required for its completion.

All attempts to inaugurate a system of foreign surveys have failed, though, with intervals of many years, spasmodic efforts have been made and expeditions sent from her shores, which have done good service to hydrography and geographical science, though many and powerful attempts have been made by those interested in commerce and navigation to induce legislators to appropriate the small amounts requisite for this service; yet, even when such have been organized, and the hydrographic work was beginning to yield its fruit, the want of interest and legislation has crushed it out, and necessitated the withdrawal of the work, leaving only the hope that in time to come the United States may assist the other great maritime nations in making more smooth the course of the mariner through the paths of the great deep. Millions of property have been lost, with thousands of valuable lives, from the lamentable neglect of continued hydrographic surveys.

LACE AND LACE-MAKING.[1]

By ELIZA A. YOUMANS.

TO think of lace merely as a symbol of vanity is quite to miss its deeper significance. If the feeling that prompts to personal decoration be a proper one—and it is certainly a natural and universal sentiment—then lace has its defense, and we may agree with old

[1] We cannot give a complete account of lace in a magazine article, but readers who desire more information are referred to Mrs. Palliser's excellent history of the subject, to which we are largely indebted, and from which our illustrations are mostly taken.

Fuller of the seventeenth century, when he says: "Let it not be condemned for superfluous wearing, because it doth neither hide nor heat, seeing that it doth adorn." But the subject has also its graver aspects; for, as science is said to obliterate all difference between great and small, so the history of lace may be said to efface the distinction between the frivolous and the serious. Though good for nothing but decoration, the most earnest elements of humanity have been enlisted in connection with it. Lace-making, a product of the first rude beginnings of art, though complex, and involving immense labor, was yet early perfected. As a source of wealth, it has been the envy of nations and has shaped state policy; as a local industry, it has enriched and ruined provinces; and, as a provocative of invention, it has given rise to the most ingenious devices of modern times, which have come into use only with tragic social accompaniments. The subject has, therefore, various elements of interest which will commend it to the readers of the MONTHLY.

Lace, made of fine threads of gold, silver, silk, flax, cotton, hairs, or other delicate fibres, has been in use for centuries in all the countries of Europe. But long before the appearance of lace, properly so called, attempts of various kinds were made to produce open, gauzy tissues resembling the spider's web. Specimens of primitive needle-work are abundant in which this openness is secured in various ways. The "fine-twined linen," the "nets of checker-work," and the "embroidery" of the Old Testament, are examples. This ornamental needle-work was early held in great esteem by the Church, and was the daily employment of the convent. For a long time the art of making it was a church secret, and it was known as nuns'-work. Even monks were commended for their skill in embroidery.

A kind of primitive lace, in use centuries ago in Europe, and specimens of which are still abundant, is called cut-work. It was made in many ways. Sometimes a network of threads was arranged upon a small frame, beneath which was gummed a piece of fine cloth, open, like canvas. Then with a needle the network was sewed to the cloth, and the superfluous cloth was cut away; hence the name of cut-work. Another lace-like fabric of very ancient date, and known as drawn-work, was made by drawing out a portion of the warp and weft threads from linen, and leaving a square network of threads, which were made firm by a stitch at each corner of the mesh. Sometimes these netted grounds were embroidered with colors.

Still another ancient lace, called "darned-netting," was made by embroidering figures upon a plain net, like ordinary nets of the present day. Lace was also formed of threads, radiating from a common centre at equal distances, and united by squares, triangles, rosettes, and other geometrical forms, which were worked over with a button-hole stitch, and the net thus made was more or less ornamented with embroidery. Church-vestments, altar-cloths, and grave-cloths, were elaborately dec-

orated with it. An eye-witness of the disinterment of St. Cuthbert in the twelfth century says: "There had been put over him a sheet which had a fringe of linen thread of a finger's length; upon its sides and ends was woven a border of the thread, bearing the figures of birds, beasts, and branching trees." This sheet was kept for centuries in the cathedral of Durham as a specimen of drawn or cut work. Darned-netting and drawn and cut work are still made by the peasants in many countries.

The skill and labor required in the production of these ornamental tissues gave them immense value, and only kings and nobles were able to buy them. But, as this kind of manufacture was encouraged and rewarded by the courts, it reached great perfection centuries ago. A search among court records, and a study of old pictures and monumental sculptures, show that it was much worn in the fifteenth century; but it was not known as lace. The plain or figured network which we call lace was for a long time called *passement*, a general term for gimps and braids as well as lace, and this term continued in use till the middle of the seventeenth century.

Lace was not only known and worn in the fifteenth century, but its manufacture at that time was an important industry in both Italy and Flanders (Belgium); while in the sixteenth and seventeenth centuries it was extensively made in all the leading countries of Europe. Two distinct kinds of lace were made by two essentially different methods. One was called point-lace, and was made with the needle, while the other was made upon a stuffed oval board, called a pillow, and the fabric was hence called pillow-lace. "On this pillow a stiff piece of parchment is fixed, with small holes pricked through to work the pattern. Through these holes pins are stuck into the cushion.[1] The threads with which the lace is made are wound upon 'bobbins,' small, round pieces of wood, about the size of a pencil, having around their upper ends a deep groove on which the thread is wound, a separate bobbin being used for each thread. By the twisting and crossing of these threads the ground of the lace is formed." The pattern is made by interweaving a much thicker thread than that of the ground, according to the design pricked out on the pattern.

The making of plain lace-net upon the pillow is thus described: "Threads are hung round the pillow in front, each attached to a bobbin, from which it is supplied and acting as a weight. Each pair of adjacent threads is twisted three half-turns by passing the bobbins over each other. Then the twisted threads are separated and crossed over pins on the front of the cushion in a row. The like twist is then made by every adjacent pair of threads not before twisted, whence the threads become united sideways in meshes. By repeating the process the fabric gains the length and width required."

[1] Sometimes lace-makers who were the wives of fishermen, not being able to buy pins, used the bones of fish as substitutes. Hence the term bone-lace.

FIG. 1.—VALENCIENNES LAPPET. Eighteenth Century.

Lace consists of two parts: a network called the *ground*, and the *pattern* traced upon it, sometimes called the flower, or gimp (Fig. 1). In modern lace we may easily distinguish the ground and pattern, but in the older laces the flowers are not wrought upon a network

FIG. 2.—HONITON GUIPURE.

ground, but are connected by irregular threads, overcast with button-hole stitch, and sometimes fringed with loops. These connecting-threads, called "*brides*," are shown in Fig. 2.

The network ground is known by the French term *réseau*. It is sometimes called *entoilage*, on account of its containing the *toile*

flower or ornament, which resembles linen, and is often made of linen thread. The terms *fond* and *champ* are also applied to it.

The ornamental pattern is sometimes made with the ground as n Fig. 3, or separately, and then worked in or sewed on (*appliqué*), Fig. 4. The open-work stitches seen in the pattern are called *modes*, *jours*, or "fillings."

All lace has two edges, the "footing," a narrow lace which serves to keep the stitches of the ground firm that it may be sewed to the garment upon which it is to be worn (Fig. 3); and the "pearl," *picot*, *couronne*, a row of little points or loops at equal distances at the free edge as shown in the figures.

The manufacture of point-lace was brought to the highest perfection by the Venetians as early as the sixteenth century. The pattern-

FIG. 3.—VALENCIENNES LACE OF YPRÈS.

books of that time contain examples of more than a hundred varieties of this costly lace. Some of these points were world-renowned for their fineness and exquisite beauty. *Point de Venice, en relief*, is the richest and most complicated of all laces. It is so strong, with its tiers upon tiers of stitches, that some of it has lasted for centuries. All the outlines are in high-relief, and innumerable beautiful stitches are introduced into the flowers. Italian influence under the Valois and Medicis spread the fashion for rich laces, and the Venetian points were in great demand in foreign countries, particularly in France. The exportation of costly laces was a source of great wealth to Venice. The making of lace was universal in every household, and the secret of the manufacture of her finest points she jealously guarded. Although both point and pillow lace were made at this time in all the leading countries of Europe, Flanders was the only rival of Italy in the markets of the world.

During the sixteenth century there was the most extravagant use of lace by the court of France. In 1577, on a state occasion, the king wore four thousand yards of pure gold lace on his dress, and the wardrobe accounts of the queen are filled with entries of point-lace. Such was the prodigality of the nobility at this period in the purchase of lace that sumptuary edicts were issued against it, but edicts failed to put down Venetian points; profusion in the use of lace only increased. The consumption of foreign lace and embroidery was unbounded. Immense sums of money found their way annually from France to Italy and Flanders for these costly fabrics. As royal commands were powerless against the artistic productions of Venice, Genoa, and Brussels, it was determined by Colbert, the French minister, to develop the lace-manufacture in France, that the money spent upon these luxuries might be kept within the kingdom. Skillful workmen were suborned from Venice and the Low Countries, and placed around in the existing manufactories and in towns where new ones were to be established.

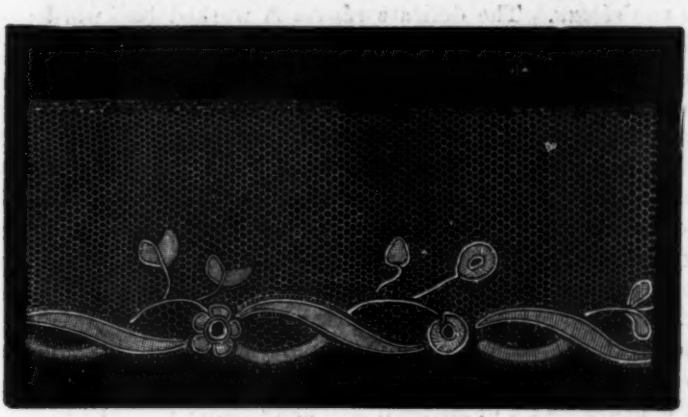

Fig. 4.—Old Honiton Application.

A declaration of August 5, 1665, orders "the manufacture of all sorts of works of thread, as well of the needle as on the pillow, in the manner of the points which are made at Venice and other foreign countries, which shall be called 'points de France.'" In a few years a lucrative manufacture was established which brought large sums into the kingdom. Point de France supplanted the points of Venice and Flanders, and France became a lace-making as well as a lace-wearing country.

The manufacture of the most sumptuous of the points de France was established by the minister at the town of Alençon, near his residence. Venetian point in relief was made in perfection in this place before his death, 1683. In all the points of this century the flowers are united *à bride* (Fig. 2), but in the eighteenth century the network ground was introduced, and soon became universal. The name

point de France for French point-lace was after a time dropped, and the different styles took the name of the towns at which they were made, as point d'Alençon and point d'Argentan.

"Point d'Alençon is made entirely by hand with a fine needle, upon a parchment pattern, in small pieces, afterward united by invisible seams. Each part is executed by a special workman. The design, engraved upon a copperplate, is printed off in divisions upon pieces of parchment ten inches long, and numbered in their order. Green parchment is now used, the worker being better able to detect faults in her work than on white. The pattern is next pricked upon the parchment, which is stitched to a piece of very coarse linen folded double. The outline of the pattern is then formed by two flat threads, which are guided along the edge by the thumb of the left hand, and fixed by minute stitches, passed with another thread and needle through the holes of the parchment. When the outline is finished, the work is given over to the maker of the ground, which is of two kinds, *bride* and *réseau*. The delicate *réseau* is worked backward and forward from the footing to the *picot*. For the flowers the worker supplies herself with a long needle and a fine thread; with these she works the button-hole stitch (*point noué*) from left to right, and, when arrived at the end of the flower, the thread is thrown back from the point of departure, and she works again from left to right over the thread. This gives a closeness and evenness to the work unequaled in any other point. Then follow the *modes* and other operations, so that it requires twelve different hands to complete it. The threads which unite linen, lace and parchment are then severed, and all the segments are united together by the head of the establishment. This is a work of the greatest nicety." From its solidity and durability Alençon has been called the Queen of Lace.

The manufacture of Alençon lace had greatly declined even before the Revolution, and was almost extinct when the patronage of Napoleon restored its prosperity. On his marriage with the Empress Marie Louise, among other orders executed for him was a bed furniture—tester, curtains, coverlet, and pillow-cases, of great beauty and richness. The pattern represented the arms of the empire surrounded by bees. Fig. 5 is a piece of the ground powdered with bees. The differences of shading seen in the ground show where the separate bits of lace were joined in the finishing. With the fall of Napoleon this manufacture again declined, and, when in 1840 attempts were made to revive it, the old workers, who had been specially trained to it, had passed away, and the new workers could not acquire the art of making the pure Alençon ground. But they made magnificent lace, and Napoleon III. was magnificent in his patronage of the revived manufacture. One flounce worth 22,000 francs, which had taken thirty-six women eighteen months to finish, appeared among the wedding-presents of Eugénie. In 1855 he presented the empress with a dress of

Alençon point which cost 70,000 francs ($14,000). Among the orders of the emperor in 1856 were the curtains of the imperial infant's cradle, of needle-point, and a satin-lined Alençon coverlet; christening robe, mantle, and head-dress, of Alençon; twelve dozen embroidered frocks profusely trimmed with Alençon; and lace-trimming for the aprons of the imperial nurses. The finest Alençon point is now made at Bayeux.

Argentan is another town in France celebrated for its point-lace, which was not inferior in beauty to that of Alençon. The flowers of

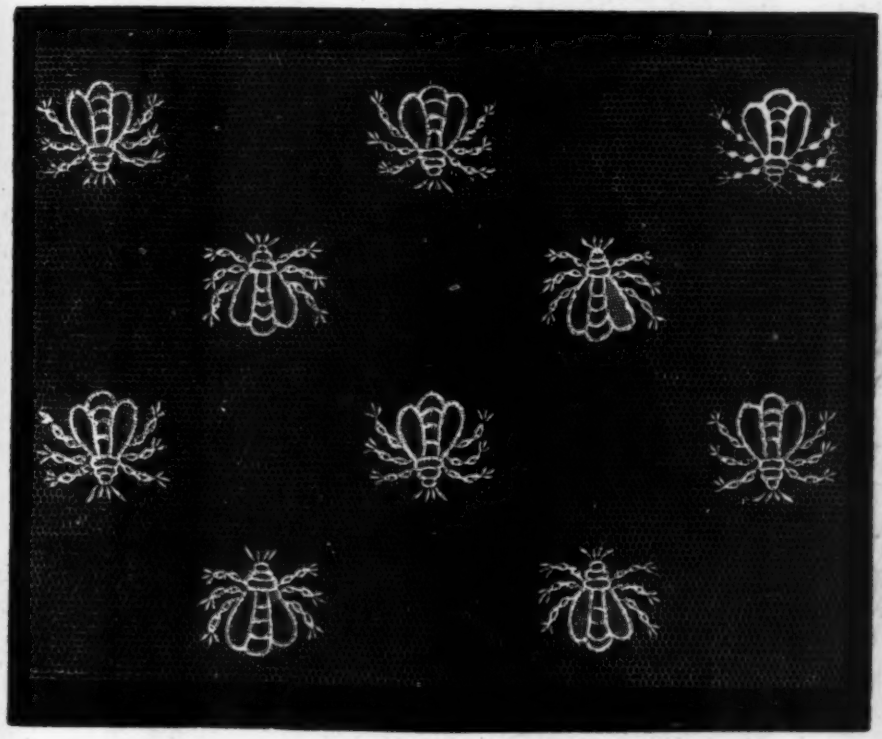

FIG. 5.—ALENÇON BED MADE FOR NAPOLEON I.

point d'Argentan, as seen in Fig. 6, are large and bold, in high-relief, on a clear compact ground, with a large, six-sided mesh. This ground was made by passing the needle and thread around pins pricked into a parchment pattern, and the six sides were worked over with seven or eight button-hole stitches on each side. It is called the *grande bride* ground, and is very strong.

While it is clear that France derived the art of making Alençon point from Italy, yet, along with all the countries of Northern Europe, Germany, and England, she is in the main indebted to Flanders for her knowledge of the art of lace-making. Flanders, as well as Italy,

FIG. 6.—POINT D'ARGENTAN.

claims the invention of lace, and, notwithstanding its glorious past, the lace-trade of Belgium is now as flourishing as at any former pe-

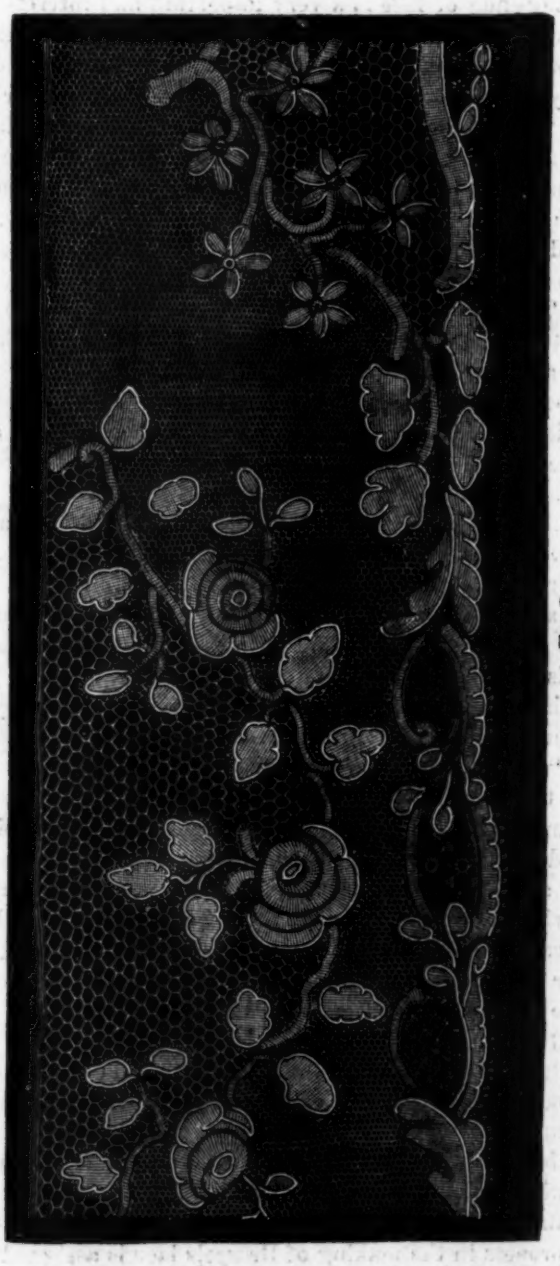

FIG. 7.

riod. Brussels lace is widely known as *point d'Angleterre*, for the reason, it is said, that in the seventeenth century the English, after vainly attempting to establish its manufacture at home, bought up

the finest laces of the Brussels market, smuggled them over to England, and sold them as English point (Figs. 7 and 8).

The smuggling of lace is a very important and interesting feature in its history. From 1700 downward we are told that in England the prohibition of lace went for nothing. Ladies would have foreign lace, and if they could not smuggle it themselves the smuggler brought it to them. "Books, bottles, babies, boxes, and umbrellas, daily poured out their treasures." Everybody smuggled.

"At one period much lace was smuggled into France from Belgium by means of dogs trained for the purpose. A dog was caressed and petted at home, fed on the fat of the land, then, after a season, sent across the frontier where he was tied up, half starved, and ill-treated. The skin of a bigger dog was then fitted to his body, and the intervening space filled with lace. The dog was then allowed to escape, and make his way home, where he was kindly welcomed, with his contraband charge. These journeys were repeated till the French custom-house, getting scent, by degrees put an end to the traffic. Between 1820 and 1836, 40,278 dogs were destroyed, a reward of three francs being given for each."

The thread used in Brussels lace is of the first importance. It is of extreme fineness, and the best quality, spun in underground rooms to avoid dryness of the air, is so fine as to be almost invisible. The room is darkened, and a background of dark paper is arranged to throw out the thread, while only a single ray of light is admitted, which falls upon it as it passes from the distaff. The exquisite fineness of this thread made the real Brussels ground so costly as to prevent its production in other countries. A Scotch traveler, in 1787, says that "at Brussels, from one pound of flax alone, they can manufacture to the value of seven hundred pounds sterling."

In former times, the ground of Brussels lace was made both by needle and on the pillow. The needle-ground was worked from one flower to another, while the pillow-ground was made in small strips an inch wide, and from seven to forty-five inches long. It required the greatest skill to join the segments of shawls and large pieces of lace. The needle-ground is three times as expensive as the pillow, for the needle is passed four times into each mesh, but in the pillow it is not passed at all. Machinery has now added a third kind of ground, called tulle, or Brussels-net. Since this has come into use, the hand-made ground is seldom used except for royal trousseaux. The flowers of Brussels lace are also both needle-made *point à l'aiguille* and those of the pillow "point plat." In the older laces the plat flowers were worked in along with the ground, as *lace appliqué* was unknown (Figs. 7 and 8).

Each process in the making of Brussels lace is assigned to a different hand. The first makes the *vrai réseau;* the second the footing; the third makes the point *à l'aiguille* flowers; the fourth, the plat

flowers; the fifth has charge of the open-work (*jours*) in the plat; the sixth unites the different pieces of the ground; and the seventh sews

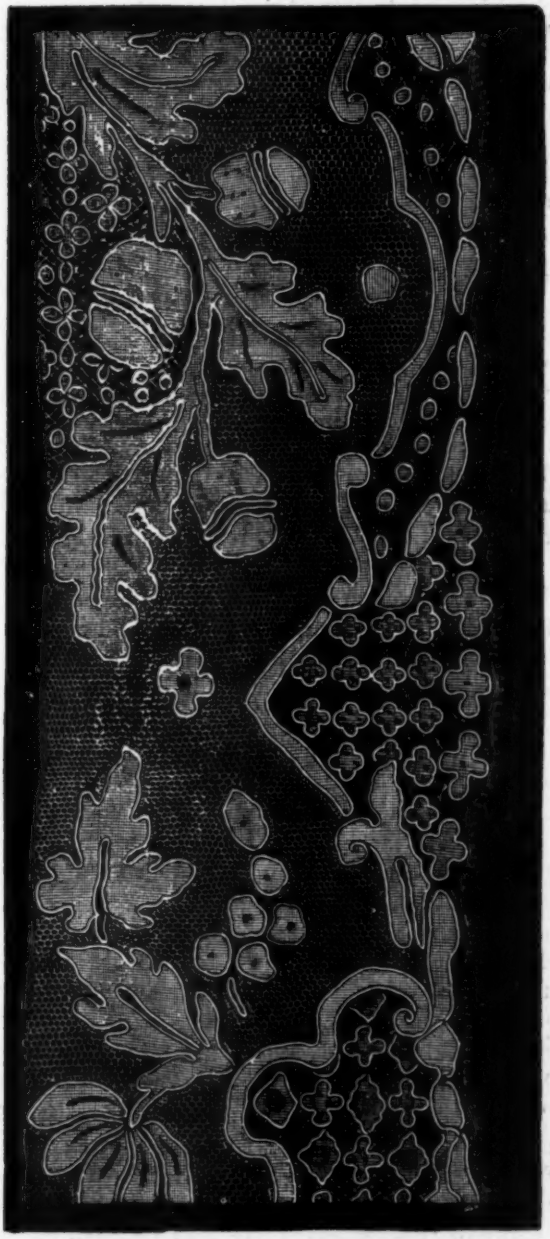

FIG. 8.—OLD BRUSSELS (POINT D'ANGLETERRE). Middle of Eighteenth Century.

the flowers upon the ground (application). The master prepares the pattern, selects the ground, and chooses the thread, and hands all

over to the workman, who has no responsibility in these matters. "The lace industry of Brussels is now divided into two branches, the making of sprigs, either point or pillow, for application upon the net-ground, and the modern *point gaze*. The first is the Brussels lace, *par excellence*, and more of it is produced than of any other kind. Of late years it has been greatly improved by mixing point and pillow-made flowers.

Point gaze is so called from its gauze-like needle-ground, *fond gaze*, comprised of very fine, round meshes, with needle-made flowers, made simultaneously with the ground, by means of the same thread, as in the old Brussels. It is made in small pieces, the joining concealed by sprigs or leaves, like the old point, the same lace-worker making the whole strip from beginning to end. *Point gaze* is now brought to the highest perfection, and is remarkable for the precision of the work, the variety and richness of the *jours*, and the clearness of the ground. It somewhat resembles point d'Alençon, but the work is less elaborate and less solid. Alençon lace, it is said, could not compete with Brussels in its designs, which are not copied from Nature, while the roses and honeysuckles of the Brussels lace are worthy of a Dutch painter. When flowers of both pillow and needle-lace are marked upon the "*fond gaze* it is erroneously called point de Venice."

Lace-making is at present the chief source of national wealth in Belgium. It forms a part of female education, and one-fortieth of the entire population (150,000 women) are said to be engaged upon it.

But some of the pillow-laces have had immense popularity as well as those of the needle. Fig. 1 is a beautiful example of the pillow-lace made at Valenciennes in the eighteenth century.

This kind of lace was first made in the city of Valenciennes, and the manufacture reached its height in that town about 1780, when there were some 4,000 lace-makers employed upon it; but fashion changed, lighter laces came into vogue, and in 1790 the lace-workers had diminished to 250. Napoleon made an unsuccessful attempt to revive the manufacture, and in 1851 only two lace-makers remained, and they were over eighty years old. At one time this manufacture was so peculiar to the place that it was said, "if a piece of lace were begun at Valenciennes and finished outside the walls, the part not made at Valenciennes would be visibly less beautiful and less perfect than the other, though done by the same lace-maker with the same thread and pillow." The city-made lace was remarkable for its richness of design, evenness, and solidity. It was known as the "beautiful and everlasting Valenciennes," and was bequeathed from mother to daughter like jewels and furs. It was made by young girls in underground rooms, and many of these workers are said to have become almost blind before they were thirty years of age When the whole piece was done by the same hand the lace was thought much more valuable.

Valenciennes lace was made in other towns of the province, but "vraie Valenciennes" only at Valenciennes. The Lille makers, for instance, would make from three to five ells a day (an ell is forty-eight inches), while those of Valenciennes would make not more than an inch and a half in the same time. Some lace-makers made only twenty-four inches in a year; hence the costliness of the lace. Modern Valenciennes is far inferior in quality to that made in 1780.

The manufacture is now transferred to Belgium, to the great commercial loss of France, for it is the most widely consumed of any of the varieties of lace. It is the most important of the pillow-laces of Belgium. Yprès, which is the chief place of its manufacture, began to make this lace in 1656. In 1684 it had only three forewomen and 63 lace-makers, while in 1850 it numbered from 20,000 to 22,000. The Valenciennes of Yprès (Fig. 3) is the finest and most elaborate of any that is now made. On a piece not two inches wide, from 200 to 300 bobbins are employed, and for greater widths 800 bobbins are sometimes used on the same pillow. The large, clear squares of the ground contrast finely with the even tissue of the patterns. The Yprès manufacture has greatly improved since 1833, and has reached a high degree of perfection. Irish Valenciennes closely resembles the Yprès lace. Valenciennes lace as fine as that of France was at one time made in England (Fig. 9).

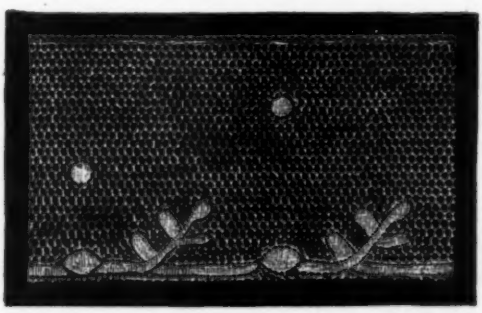

FIG. 9.—VALENCIENNES, NORTHAMPTON, ENGLAND.

Mechlin is a fine, beautiful lace, made in one piece on the pillow, and is distinguished by the flat thread which forms its flower. Before 1665 all pillow-lace, of which the pattern was relieved by a flat thread, was known as Mechlin lace. "It is essentially a summer lace, not becoming in itself, but charming when worn over color."

Silk laces were first made about 1745. At first this new fabric was manufactured from silk of the natural color brought from Nanking and it was hence called *blonde*. After a time, however, it was prepared from the purest and most brilliant white silk. "Not every woman can work at the white lace. Those who have what is locally termed the *haleine grasse* (greasy breath) are obliged to confine them-

selves to black." To preserve purity of color it is made in the open air in summer, and in winter in the lofts over cow-houses, as the warmth of the animals enables the workers to dispense with fire, which makes more or less smoke. The most beautiful blondes were once made at Caen, but competition with the machine-made blondes of Calais and Nottingham has caused the manufacture of white blonde to be abandoned at this place, and its lace-makers now confine themselves to making black lace.

The manufacture of black-silk lace was first established in the town of Chantilly, near Paris, and hence, wherever this fabric is now made, it is called "Chantilly lace." It is always made of a lustreless silk, called "grenadine," which is commonly mistaken for thread. As it was only consumed by the nobility, its unfortunate producers became the victims of the Revolution of 1793, and perished with their patrons on the scaffold. This put an end to the manufacture for many years; but in 1835 black lace again became fashionable, and Chantilly was once more prosperous. But the nearness of Chantilly to Paris has, of late, increased the price of labor so much that the lace-manufacturers have been driven away. The so-called Chantilly shawls are now made at Bayeux. The shawls, dresses, and scarfs, that are still made at Chantilly are mere objects of luxury.

The black laces of Caen, Bayeux, and Chantilly, are identical. The shawls, dresses, flounces, veils, etc., are made in strips and united by a peculiar stitch. Great pains are taken in Bayeux in the instruction of lace-makers, so that the town now leads in the manufacture of large pieces of black lace. Fig. 10 represents a sample of this lace of the finest quality and of rich design.

Each country has furnished its special style of lace—Italy its points of Venice and Genoa; Flanders its Brussels, Mechlin, and Valenciennes; France its point d'Alençon and its black lace of Bayeux. England has also produced its unique Honiton, and Spain its silk blondes. Each of these laces is made in other countries, but in its characteristic lace each nation is unrivaled.

Honiton lace, the only original English lace of importance, was first made at Honiton, in Devonshire, in the seventeenth century. The art of lace-making is said to have been brought into England by Flemish refugees, and Honiton lace long preserved an unmistakable Flemish character. It is to its sprigs that it owes its reputation. They are made separately, and at first they were worked in with the pillow-ground; afterward they were sewed on, as shown in Fig. 4, which is a sample of the Honiton of the last century. The net is very beautiful and regular. It is made of the finest thread, brought from Antwerp at a cost of $350 per pound. There was no thread to be found in the British Islands fit for the purpose. Cotton thread, perhaps, might be had, but not the linen thread necessary in a work requiring so much labor, which alone would make it very costly.

The manufacture of a piece of net like this, eighteen inches square, cost $75, and a Honiton veil often cost a hundred guineas.

At the time of the marriage of Queen Victoria, the manufacture of Honiton lace was so depressed that it was with difficulty the necessary number of lace-workers could be found to execute the wedding

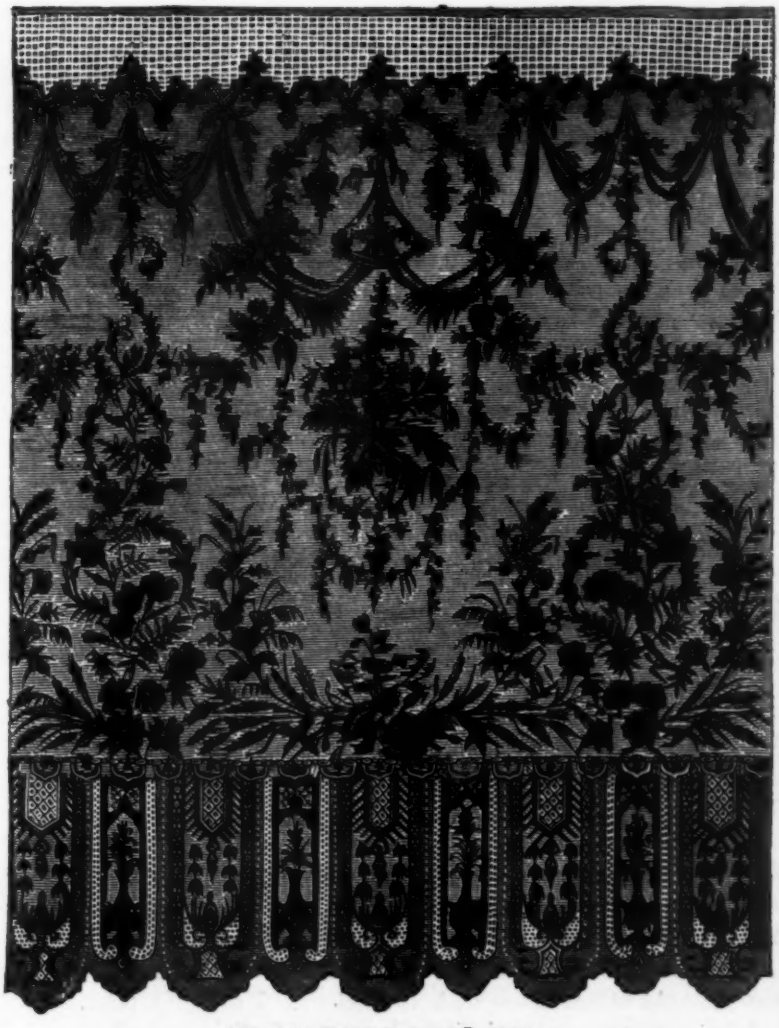

FIG. 10.—BLACK LACE OF BAYEUX

lace. Her dress cost £1,000, and was composed entirely of Honiton sprigs, connected on the pillow by a variety of open-work stitches. Fig. 11 is one of the honeysuckle sprigs from a flounce afterward made for her Majesty. "The bridal dresses of their royal highnesses the Princess Royal, the Princess Alice, and the Princess of

Wales, were all of Honiton lace, the patterns consisting of the national flowers, the latter with prince's-feathers intermixed with ferns, and introduced with the most happy effect." These sprigs are joined with the needle by various stitches, forming Honiton guipure, Fig. 2, which, in richness and delicacy, is by many thought to surpass the fine

Fig. 11.—Honeysuckle Sprig of Modern Honiton.

guipure of Belgium, known as *duchesse* lace. "The reliefs are embroidered with the greatest delicacy, and the beauty of the workmanship is exquisite."

Valenciennes and Mechlin were the first laces in which the ground was wrought in one piece with the design. Until this time all lace had been *guipure*—that is, it had consisted of open embroidery, in which the figures were connected by *brides* without any thing like a background. The network ground, which we now take to be the essential thing in lace, was not thought of till the end of the seventeenth century. The word *guipure* means a thick cord over which silk, gold, or silver thread, is twisted. In the seventeenth century this guipure, or *guipé*, was introduced into lace to imitate the high-

reliefs of needle-made points. These were guipure laces. The name has since been applied to all laces without grounds that have the patterns united by brides. The bold, flowing figures of Belgium and Italy, joined by a coarse network ground (Fig. 12), are also called guipure.

The *guipure* called Cluny, with its geometrical patterns, is a recent lace which derives its name from the circumstance that the first patterns were copied from specimens of old lace in the Musée de Cluny.

Thus far we have only spoken of hand-made lace, which, in Italy, was a purely domestic industry. It was made by women at home,

FIG. 12.—GUIPURE. Seventeenth Century.

and each piece of work was begun and finished by the same hand. But, when the statesman Colbert introduced the manufacture into France, the principle of the division of labor was adopted, and the work was done in large factories. By degrees, as we have seen, fine needle-made net replaced the bride-ground in costly laces, and cheaper laces of the same style were made upon the pillow. The sprigs were at first worked into the net; but at length, in the Valenciennes and Mechlin laces, the figure was made along with the ground, and it was the immense success of these laces which led to the invention and perfection of lace-machines, so that now almost every kind of lace is made by machinery, and often so perfect that it is difficult for experts to detect the difference.

"The number of new mechanical contrivances to which this branch of manufacture has given rise is altogether unparalleled in any other department of the arts." It was in 1764, a little more than a hundred years ago, that pillow-made net was first imitated by machinery. It was called frame-looped net, and was made by using one thread, as in hosiery, and, like hosiery, the lace would ravel when this thread was broken. The machine was, in fact, a modification of the stocking-frame. It was so much improved from time to time that net with six-sided meshes could be made, which, when stiffened, looked like cushion-net, but when damp it would shrink like crape.

Another machine was devised for making lace, called the warp-frame. The lace made by it, like the former, consisted of looped stitches, but a solid web was produced, which could be cut and sewed like cloth. In 1795 lace open-work was made by this machine, and soon afterward durable and cheap figured laces, in endless variety. "The lightest gossamer blond silk laces, cotton tattings and edgings, antimacassars and d'oyleys, threaded and pearled, are finished in this loom, and are the pioneers of higher-priced lace articles throughout the world. In 1810 there were four hundred warp-looms at work making the lace called Mechlin-net, and using cotton yarn costing fifteen guineas the pound."

But the most important step ever taken in the making of lace was the invention of the bobbin-net machine. Until this invention machine-lace was, for the most part, only a kind of knitting that had to be gummed and stiffened to give it the solidity of net. The great problem of the time was how to imitate pillow-made net by machinery. Numerous attempts to do this were made by smiths, weavers, and lace-makers. Much inventive talent was vainly spent, and many men of genius fell into poverty through their prolonged and unrequited efforts to construct the required machine. Insanity and self-destruction had ended the careers of some, and disappointment and misfortune befell them all, until at last the idea of such a machine was regarded as visionary—it was classed with the perpetual motion.

John Heathcote, the inventor of the bobbin-net machine, was born in 1783. In youth he was remarkable for his quick acquisition of knowledge, his thoughtful intelligence, and quiet deportment. He was early placed at the hosiery manufacture, and at the age of sixteen he conceived the idea of constructing a machine to make lace. In 1804 he was at work as a journeyman at Nottingham, and is thus described by his employer: "Heathcote showed that he had already attained to a thorough knowledge of mechanical contrivances; was inventive and persevering; undaunted by difficulties or mistakes and consequent ill-success; patient, self-denying, and very taciturn. But he expressed surprising confidence that, by the application of mechanical principles to the construction of a twist-net machine, his efforts would be crowned with success." Being determined to construct a

machine for making twisted and traversed net,[1] he removed to a place where he could secure privacy and the constant sight of lace-making upon the pillow. During the time between 1805 and 1808 he perfected and patented his first machine, by which he could make a breadth of traversed and twisted net three inches wide. It was pronounced by Lord Lyndhurst "the most extraordinary machine ever invented; but he at once broke it up, and in 1809 patented another, which would make a wider net and had many other advantages.

"Cushion-made net had half the threads proceeding in wavy lines from end to end of the piece, and may be represented by warp-threads. The other threads, lying between the former, pass from side to side by an oblique course to the right and left, and may be called weft-threads. If the warp-threads could move relatively to the weft-threads so as to effect the twisting and crossing, but without deviating to the right or left hand, and if the weft-threads could be placed so that all of them should effect the twisting at the same time, and one-half of them should proceed at each operation to the left and the other half to the right hand (a substitute being also provided for the cushion-pins), lace would be made exactly as on the cushion." The machine patented by

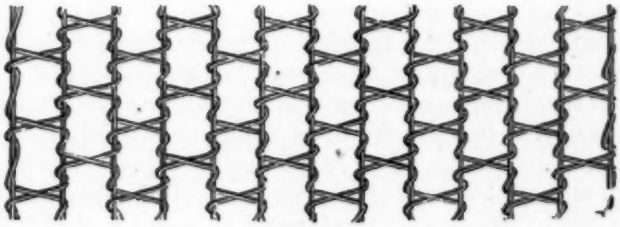

Fig. 13.

Heathcote secured these results, and increased the production over the pillow-worker a thousand-fold. The courses of the threads forming the meshes of the bobbin-net frame may be seen in Fig. 13. When taken off and extended to their proper shape the meshes have the appearance shown in Fig. 14.

This wonderful machine was produced by the unaided mechanical skill of Heathcote; but in constructing it he met with such difficulties as led him long after to say that, "if it were to be done again, he should probably not attempt to overcome them." He was only twenty-six years old when he took the second patent. In 1813 he patented various improvements upon it and reduced the number of movements necessary to make a row of meshes. The machine of 1809 employed sixty movements to make one mesh, which is now done by twelve. It made one thousand meshes a minute, and only five or six could be made by hand. A machine of the present day produces thirty thou-

[1] Net in which great numbers of threads were made to twist with or wrap round each other, and to traverse, mesh by mesh, through a part or the entire width of the frame.

sand in the same time. This industry is said to surpass all others in the complex ingenuity of its machinery.

One of the machines used in its production is said by Dr. Ure to be as much beyond the most curious chronometer in multiplicity of mechanical device as that is beyond a common roasting-jack.

In 1811, when prices had fallen, a Vandal association at Loughborough paraded the streets at night with their faces covered, and armed with swords and pistols, and, entering the workshops, they broke the machines with hammers; twenty-seven machines were destroyed in Heathcote's factory. In 1816 fifty-five more were destroyed

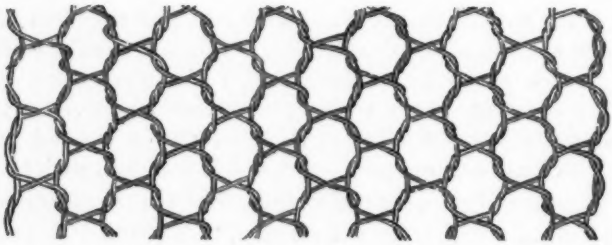

FIG. 14.

by the same society. Of the eight men who conspired in the attack on Heathcote's factory, six were convicted and hung and two transported for life. Heathcote's loss was estimated at $50,000, which the authorities offered to make up to him if he would reëxpend the money in the county. This he refused to do, and the result was that he left Loughborough and settled at Tiverton, where he remained until his death in 1861. Heathcote employed his mechanical skill with unwearied energy in improving the lace-manufacture. From 1824 to 1843 he was constantly busy with inventions, and he represented Tiverton in Parliament from 1834 to 1859.

"Bobbin-net and lace are cleaned from the loose fibres of the cotton by the ingenious process of gassing, as it is called, invented by the late Mr. Samuel Hall, of Nottingham. A flame of gas is drawn through the lace by means of a vacuum above. The sheet of lace passes to the flame opaque and obscured by loose fibre, and issues from it bright and clear, not to be distinguished from lace made of the purest linen thread, and perfectly uninjured by the flame." The progressive value of a square yard of plain cotton bobbin-net is thus stated: In 1809, $25; 1813, $10; 1815, $7.50; 1818, $5; 1821, $3; 1824, $2; 1827, $1; 1830, 50 cents; 1833, 32 cents; 1836, 20 cents; 1842, 12 cents; 1850, 8 cents; 1856, 6 cents; 1862, 6 cents.

In 1823, when Heathcote's patent expired, water and steam power had already begun to take the place of hand-labor, and lace-machines rapidly increased in numbers. Men of all ranks and professions, clergymen, lawyers, and doctors, embarked capital in the business, and

all Nottingham went mad. Mechanics flocked to the scene, dwellings could not be had, and building-ground sold for $20,000 an acre. "Thousands of pounds were paid in wages to men who had not seen a twist-machine, and tens of thousands for machinery that could never repay the outlay. Improvident men rode to their work, stopping for drinks of port and claret by the way, and were seen years afterward receiving parish pay. When the national frenzy of 1825 collapsed, the effect of this local inflation was fearful. Visions of wealth were at once dissipated; many in and out of the trade fell into poverty, or became exiles, and some destroyed themselves."

The extent of the manufacture of lace by machinery in England is immense. In 1866 there were 3,552 bobbin and 400 warp machines, yielding £5,130,000. There has been no actual census since then, but in 1872 the returns were certainly not less than £6,000,000.

In France, in 1851, there were 235,000 cushion-lace makers, producing annually £3,000,000, the whole European production in hand-made lace being £5,500,000. The bobbin-net machines and warp frames are extensively used in France, and twenty years ago there were 50 bobbin-net machines in Belgium, making very fine extra twist-net on which cushion sprigs are applied.

The invention of machinery for lace-making, however, has not diminished the consumption of costly hand-made laces. The rich seem more eager than ever to obtain the finer products of the needle and pillow, insisting that the touch, finish, and beauty, of such laces can never be attained by the products of the lace-frame. On the contrary, the writer was recently assured, by the foreman of a leading lace establishment in London, that no hand-made ground could compare in beauty and perfection of workmanship with some of the exquisite grounds now made by machinery.

OUR GREAT AMERICAN UNIVERSITY.

ABOUT five years ago we decided to found a new college. At that time our denomination had but seven in the State, not one of them first class, all beggarly, and the nearest fifty miles away. Brother A—— alone demurred to the project, but, as he was more noted for mere abstract scholarship than for practical attainments, his objections were easily set aside. He thought it would be very unwise to establish another institution of learning, on the ground that the prevalent division of forces tended to lower educational standards; and he held that we ought rather to concentrate our energies upon schools already in existence and struggling to get along. We, on the other hand, urged the desirability of multiplying means of education. If

one college is a good thing, surely two must be twice as good, and so on, indefinitely. Why, then, should we not have a college of our own, and train up our young men at home, instead of sending them away to institutions established in distant places for the gratification of wretched local pride? Besides, the nearest university to us was that hot-bed of infidelity founded by the State, and there was great danger lest our youth should go there and become corrupted. Such a catastrophe must be prevented at all hazards.

But one argument influenced us above all others, and was, in fact, unanswerable: we had in our midst a very prominent man, the Hon. Magnus Virtue, who, after accumulating a large fortune in the management of a distillery, had lately retired from business, and joined my church. Out of the goodness of his heart, and encouraged by my exhortations, he decided to become a public benefactor, and accordingly offered us $20,000 for the foundation of a great college to be called by his ever-to-be-revered name. Here, then, was an opportunity which we ought not to neglect. Twenty thousand dollars was a most munificent gift, and would found an institution better endowed at the start than any of our near rivals, except perhaps the political abomination already mentioned. Twenty thousand dollars meant a fine building; and surely students' fees would suffice for the expenses of running. As for libraries, apparatus, etc., we could easily rely upon donations and bequests which would, of course, come pouring in upon us as soon as we were well established.

So we organized a board of trustees, procured a charter, and set to work under the title of "Virtue University." This, we thought, had a grander sound than "Virtue College," and we well knew how much the public is influenced by names. Shakespeare's absurd statement about the odor of a rose is contradicted by universal experience.

The first great task before us was, plainly, the erection of a building; and this involved the choice of a site. Here we were very fortunate. One of my parishioners, a noted real-estate broker, happened to own a worn-out farm some two miles from town, and was anxious to bring it into market. He was a man who clearly recognized the duty of casting his bread upon the waters whenever a fair prospect of speedy return with interest was discernible; and so he presented us with five acres of said land, situated on the top of a steep bluff a quarter of a mile from the nearest road. The gift, of course, advertised the rest of his estate, which he at once cut up into building-lots, and sold at a handsome profit. He got his money, and we got our site, so both were satisfied. Far be it from me to impugn or even to suspect his motives. Of course, our building was begun without delay.

Meanwhile we went vigorously to work manipulating the newspapers, both secular and religious. Every week we caused some item to appear concerning the progress and prospects of "Our Great American University." Rumors of expected bequests, and specula-

tions about the Faculty were continually finding their way into print. Our university was to be a model to all other institutions. Although controlled by our denomination, it was to have no sectarian bias; its policy should be conservatively liberal; morally, intellectually, and æsthetically, it might be regarded as the culmination of our American school-system. Men of national reputation and the greatest ability were to fill professors' chairs; thorough instruction could be expected in every department; languages, literatures, sciences, philosophy, and art, would occupy the time of the students who were sure to flock in from all parts of the country. We hoped to eclipse all the colleges of America, and even to rival the greatest universities of the Old World. Statements like these, capable as they were of great latitude in interpretation, served the double purpose of interesting the general public, and of keeping up our own enthusiasm.

At last our building was finished—a splendid brick structure with a French roof, a tower, and a belfry. Even a New York architect, who visited our town, expressed his wonderment and surprise at it. Of course we were proud of our work, but that pride was lessened when we discovered that the $20,000 was all expended. The building had absorbed it completely, and half as much again; so here we were, at the end of our tether, with a fine pile of brick-and-mortar, no money, and a very handsome debt. What was to be done? Our trustees met, and, since most of them were clergymen, this question was promptly answered. We must appeal to the public. We did so—begged vigorously on week-days, took up a collection on Sundays, and, in the course of a month, managed to raise about $3,000. This went to the builder, who, for the rest of his claim, generously accepted a mortgage bearing eight per cent. interest.

This unfortunate matter rather cast a damper upon our spirits, but still we were determined to go along. Here was a debt upon which interest must be paid, and how could we pay it except by opening the university and deriving some income from students? We expected 500 students at $50 per annum each, making $25,000 a year to begin with, exclusive of gifts and bequests. We could allow $2,000 a year for interest and sinking-fund, $8,000 for incidental expenses, and all the rest might go to pay instructors. Seven professors, at $1,800 apiece, with a president at $2,500, would give us indeed a strong Faculty. So we went bravely ahead on the strength of these calculations. Adversity only seemed to make our anticipations more glowing than ever. Such is the power of faith.

All this time Brother A——, who had, unfortunately, become a member of the board, was a thorn in our flesh, and a stumbling-block in our path. Not a step was taken without opposition from him; indeed, he seemed to consider himself a monitor over all our official actions. The conceit of these scholars is amazing! He opposed the erection of our building as an extravagance, urging that a university needed

brains more than mere brick-and-mortar. When we decided to get brains, he again annoyed us, saying that we ought not to employ professors until we were sure of our ability to pay them. Such inconsistencies were naturally self-destructive; so we listened politely to his wild and extravagant ideas, then quietly ignored whatever he said, and did as we had previously determined. Other colleges had fine buildings, contracted debts, and worked on the sure foundations of faith, hope, and (to be received) charity. We would follow the common example, and succeed. To this Brother A—— added that other colleges sometimes failed, and so might ours; but I, for one, could not understand the relevancy of the remark.

So the board agreed, with but one dissenting voice, to appoint a Faculty. The next step led to squabbles. Every member had some *protégé* to provide for; each one desired that certain chairs should be established and others omitted—no two could agree altogether. First, of course, we decided to choose a president, for a college without a president would be like a house without a roof. We would, therefore, appoint a president, and then let him advise us what to do next; although taking his advice might be quite another matter. As was to be expected, Brother A—— again interfered, saying that a president would be a useless expense; that he would merely draw the highest salary and do the least work of any member of the Faculty. To sustain his arguments he called our attention to the fact that the German universities have no presidents, whereupon I jocosely remarked that "they could afford no precedent for us." With their infidel tendencies they are indeed bad exemplars, and it would be a great pity if any free American institution should ever copy after them.

After a long and tedious discussion we at last fixed our choice upon a prominent Eastern clergyman, and offered him the splendid salary of $2,500 dollars a year. His parish, however, paid him $6,000, and so he gratefully declined our proposition. Several other ventures resulted in the same way, and thus three months passed with nothing accomplished. Finally, the lightning struck in a most unexpected quarter, and I, the humble writer of these pages, was really chosen President of Virtue University. This choice was opposed by Brother A—— with more than his usual bitterness; why, I never could quite understand. He disclaimed all personal feeling in the matter, professed great esteem for me, and all that sort of thing, but thought I was hardly qualified for the place. He pointed out that I had had no experience in educational affairs; that I was a graduate, not of a college, but only of a theological seminary; and stoutly maintained that we ought to choose either a thoroughly-trained educator or nobody at all. Now, it was well known that I had successfully, not to say brilliantly, served several terms upon the school committee; and also that I had once been chaplain of a small college in the northern part of the State. These facts, coupled with the shrewd suspicion that Brother

A—— would like the appointment for himself, gave me the election. I at once entered upon my duties, and began to draw salary. This was in May, and the university was to open in September. Meanwhile, I was to raise money; so, after first giving my views concerning the Faculty, I started for New York, begging. In two months I contrived to secure $1,500 over my expenses, and then returned in only a very moderate state of jubilation. Why is it that rich men care so little for the cause of education?

At last the composition of our Faculty was determined, as follows: I, as president, was to teach mental and moral philosophy, logic, and finance. Brother A—— ironically suggested that perhaps I had better undertake five or six other branches in addition to these, but I did not feel like being overworked. For professors we were to have one of Latin, a second of Greek, a third of mathematics, a fourth of history, a fifth of English literature and rhetoric, a sixth of modern languages, and a seventh of chemistry and natural philosophy. As was to have been expected, Brother A—— bothered us again, urging that, as long as we were determined to appoint professors, we ought to do fuller justice to the sciences. But these are comparatively unimportant, as well as rather unsafe, branches of knowledge (if, indeed, they can be called true knowledge at all), and therefore we adhered to the scheme given above. We did, however, draw up a long plan of studies, including every prominent subject we ever heard of, and in it relegated astronomy, botany, natural history, and geology to the senior year of the college course. They could be taught at the proper time without special professors. This plan or programme we constructed in the most thorough manner, arranging hours for each professor, fixing text-books, and stating in which rooms given recitations should be heard. One of our members—it is easy to guess who—broached the subject of elective studies, but the rest of us discountenanced all such experiments. We felt able to arrange a better course of studies than any student could devise, and held firmly to the idea that what was best for one was best for all. With the needs of students after graduation we had nothing to do. As for text-books, not a new one appeared on our list; we chose only such as were old and well tried; that on chemistry, for instance, was the same which I had studied in the Sleepyville High-School thirty years before. When our professors arrived they annoyed us a good deal about changing, but we firmly adhered to our early decisions. The scheme of hours, however, we did have to rearrange, for in practice it would not work. We had planned it in such a way that sometimes one professor would have to hear two different classes in different rooms at once; and in other instances the students were required to be similarly ubiquitous.

I have already mentioned the fact that the election of professors was attended by much dissension in our board. This began, as usual,

with Brother A——, whose notions were always of the most unpractical kind. He wanted us to employ specialists; men who understood thoroughly the branches they professed to teach, and who would be independent of text-books. According to his extravagant ideas, every department of knowledge is in rapid growth, and only a man who devotes himself assiduously to one study is able to teach that study in accordance with the requirements of modern times. Such nonsense as this we repudiated. Anybody of ordinary education and intelligence ought to be able to teach any subject by simply taking a text-book and keeping a lesson or two ahead of the class. As for "advanced knowledge," the "requirements of modern times," and all that sort of thing, we distrusted it totally; under such disguises, specious and pleasing, dangerous ideas would be sure to creep in and sap the foundations of our university. We must have nothing rash nor novel in our institution; only well-tried and approved knowledge should be taught by the professors. These must be, first, men of trained moral character and good denominational standing; mere familiarity with this, that, or the other study, should be a purely secondary matter.

At last, after much ill-feeling all round, our professors were appointed. Four of them were esteemed clergymen of our denomination, who, having failed at preaching, were glad to find some occupation. Thus, in divers ways, does a great university benefit the human race. Another member of the Faculty was a recent graduate of our leading theological seminary, who accepted a chair until he could find a pulpit; two others were lay brethren. We had our greatest difficulty in selecting a professor of chemistry. Several gentlemen applied, were discussed, and rejected, before we made our final choice. One, the special *protégé* of Brother A——, had just returned from Germany, where for three years he had been studying at Heidelberg under a certain Prof. Bunsen, who was reputed to be a very great man, but of whom we had never before heard. This young man brought strong recommendations, but appeared to be dangerous; so, as he was not a member of our sect, we rejected him. Another we were about to elect, when we discovered that he was a Darwinian and a reader of Tyndall; so he could not by any means be chosen. At last we found an apparently harmless young gentleman who had just graduated from an Eastern scientific school, and him we made our professor. Now a notable event happened. Brother A—— made a suggestion which was actually followed; namely, that we should buy some apparatus and chemicals. We at once voted to spend three hundred dollars (recently begged) for fitting up a laboratory, and appointed a committee to look after the matter. At the next meeting of the board they reported the purchase of an air-pump, an electrical machine, some acids, a little phosphorus, a large gas-bag, and several retorts. These being the appliances most frequently mentioned

in general literature, they were undoubtedly the proper things to have; and we considered the professor lucky in having them. Brother A—— was, of course, dissatisfied with the whole proceeding. He thought that the money should have been placed at the disposal of our professor, who knew best how to expend it; and he also grumbled because our committee had not bought something called a spectroscope. Such an instrument was never heard of in my days, so I suspected it of some occult connection with spiritualism, and expressed myself accordingly. What has science to do with spectres? The instrument was never bought.

Before the university opened, all the moneys collected during my Eastern trip, together with minor sums contributed at home, were expended. All sorts of unforeseen expenses kept rising before us. There was furniture to buy, of course, and maps, and stationery, and books. Indeed, a library was indispensable, so we voted to invest a thousand dollars in books, and placed this sum in the hands of a committee, of which I was chairman. I think few committees could have done better than we did. Many valuable works we obtained very cheaply from a second-hand dealer in New York; scarcely a new book was purchased. We were especially careful not to get any thing which might prove injurious to our young men; not a volume of Darwin, Tyndall, or Spencer (except the "Faery Queene"), has to this day found its way upon our shelves. No, indeed! we bought good editions of the old pagan authors, and the works of the early fathers, and full sets of the sermons published by the leading lights in our own denomination. We had also a few histories, some of the poets, and two or three worn-out schoolbooks upon chemistry and natural philosophy. I doubt whether any college in the world could show a more respectable and less dangerous library than the one which we collected.

At length all was ready for opening. Our professors were on hand, our building furnished, our money spent. Now for the rush of students eager to partake of the intellectual feast so cheaply offered to them. We had all been very busy drumming up recruits, and confidently expected a large class; but only thirty appeared. Out of these, twelve were studying for the ministry, and expected tuition free. Only eighteen paying students, yielding us an income of $900 a year; and this when we had calculated upon $25,000! Why, it would pay little more than the interest on our debt, to say nothing of professors' salaries. In this terrible emergency, the Hon. Magnus Virtue again became our benefactor. I myself went boldly to him, and told how we were situated. Said I: "The university bears your name; if it fails, your reputation will suffer; 'he that giveth to the poor lendeth to the Lord.'" He grumbled a good deal at what he called our "wretched mismanagement," and especially at our extravagance in the matter of teachers' wages. "Why should we pay a

professor nearly $2,000 a year, when he had always been able to get plenty of clerks to work in his office for $600?" Finally, after much argument, he gave us $10,000, unaccompanied by his blessing. This relieved our embarrassments for the time being, and we went along quite swimmingly for the rest of the year.

I wonder if there was ever a college whose professors and trustees did not occasionally disagree? We certainly had now and then a squabble to vary the monotony of our labors, and were obliged in the board more than once to reverse decisions of the Faculty. But our chief difficulty was with the chemist, whose ideas upon some subjects were, to say the least, extravagant. To begin with: he wanted more apparatus, said he could do nothing with the "meagre" supply we had given him, and spoke rather disrespectfully of the committee which bought it; he actually referred to certain trustees as "idiots" (perhaps meaning Brother A——), which may have been true, but was unquestionably uncivil. It was in vain that I tried to convince the young man of his unreason; I urged my superior age and experience, and finally was obliged to crush him by saying, in my most polite and dignified manner, that I had probably studied chemistry before he was born, and that my teacher had succeeded brilliantly with no apparatus at all. He also bothered us for more books; so we gave him twenty-five dollars to buy them with, and thus silenced him for a while. That money he actually spent for works in foreign languages which neither I nor any student could read. Such is a result of trusting to the judgment of a professor. In the spring our chemist again broke out in the most absurd manner. It so chanced that some of our students had entered in advanced classes, a circumstance for which we failed to provide beforehand, and upon the list of studies framed by us they found certain branches which they wished to pursue. Among these were the treacherous and valueless natural sciences, for which we had no professors. It was at once found necessary that these things should be taught: and who was to teach them but the Professor of Chemistry and Natural Philosophy? We intimated to that gentleman that such work devolved upon him, and he objected most irrationally. He claimed that his business was to teach chemistry and physics (as he called natural philosophy, though what that branch has to do with medicine I never could see), and refused to undertake any thing else. How unreasonable! We only asked him to hear a few extra recitations in astronomy, natural history, physiology, botany, and geology, and he must needs object! He said that he was a chemist, and knew nothing of these other sciences; that each of them was the life-work of a specialist; and that no man living was competent to undertake even the tenth part of such a task. As we knew perfectly well that twenty other colleges in the State employed men who did precisely what he said no man could do, we insisted; and the upshot was that he resigned. Then the trustees passed an

ordinance to the effect that any professor in the university could be called upon to teach any branch, upon penalty of dismissal if he refused. We were determined that our teachers should be men of broad general culture, and not mere narrow specialists. Of course, every one of them had studied a variety of branches at school or college, and surely any man ought to be able to teach any thing which he himself had ever learned. Brother A—— objected to our entire proceeding, but we paid no attention to him. Still, his remarks about "smatterers" and "educational fraud" could not but be somewhat offensive.

In the course of the year our university received a few minor gifts, and at commencement we found ourselves with the debt not very much increased. Our teachers were nearly paid, but the treasury was again empty. Two students graduated; and for them we had grand public exercises, which closed with an appeal to the people for support. This meant money, and brought in about $500. Upon such driblets our institution was obliged to run. We must evidently retrench, and we did so by reducing the number of professors and cutting down salaries. My own salary was untouched, however; but then, instruction in rhetoric and English literature was added to my former duties. The professors were to receive $1,000 per annum each, instead of the $1,800 paid hitherto, and were to be only three in number. These three were of course selected from among the unfortunate ex-clergymen who served in our original Faculty. One was to teach ancient languages and history; another modern languages and history; the third gave instruction in mathematics, political economy, and Oriental tongues. The latter item we thought would look well in our catalogue, and, as the professor had learned Turkish and Arabic when a missionary during his youth, we put it in. To be sure, he had about forgotten both languages, but, as he was never actually called upon to teach them, that made little difference. As for the "natural sciences," we decided to pass them around. For instance: I would teach chemistry the first year; then the professor of mathematics was to take it; and so on in order through the Faculty until it came my turn again. Thus we avoided the confusion and annoyance due to the presence of a scientific specialist upon our working staff. Now and then, of course, trifling difficulties arose in consequence of our unfamiliarity with the minor details of science. For example: our classical professor undertook to teach botany the other day, and attempted to show his students how a flower might be analyzed. He selected a buttercup for purpose of illustration, went through his analysis, as he thought, according to the book, and made the flower out to be a water-lily. His students would have lost confidence in him had he not dexterously attributed his error to misprints in the botany! But what are such trivial matters in comparison with the great essentials of education?

This reorganization of the Faculty meant the reorganization of the

entire university, and two entirely new features were introduced into it. We established a preparatory department under a lady teacher, and we voted to admit female students to all of our classes. The latter measure was adopted rather hesitatingly, having been in a sense forced upon us by stress of circumstances. We must have students at any rate, and if we could not get young men we would take young ladies. The impropriety of thus mingling the sexes was evident to all except Brother A——, who alone really favored the step taken; and the uselessness of higher education to women was also obvious. How can women apply Latin and Greek to their household duties, I should like to know? What business have they with mathematics? My own wife never learned these things, and she has been certainly none the worse wife to me. But, notwithstanding my apprehensions, the dangerous move was made, and in consequence I have had tribulation ever since. Not that any scandal has resulted; not that any wrong has been done; our troubles come from a totally different source. These pestilent girls are teasing us to teach them all sorts of out-of-the-way things: one wants to learn the calculus, of which our mathematical professor is ignorant; another asks for a laboratory course in chemistry such as we are unable to give, and so on. Unhappy for us was the day that we permitted our thirteen young women to enter the university. They tell tales about us outside, and thus injure our reputation. We cannot get rid of them, and what *are* we to do?

But troubles like these were trifling in comparison with our anxiety upon pecuniary matters. Counting in our new preparatory department we had a few more students than before, but not enough to yield us the income we needed. The money-question, then, kept staring us in the face, and no measure we could devise ever quieted it more than just temporarily. One move was taken at commencement-time—a move due to my remarkable executive genius—which seemed to tide us over several months of our trials. We gave the degree of LL. D. to every millionaire in our county, and made a number of our popular clergymen doctors of divinity. The millionaires took the bait readily, and all save one gave us handsome sums, varying from $500 to $2,000. The single exception was a retired coal-dealer, who refused to accept the proffered degree, saying that he knew nothing about laws and did not want to doctor them. Shortly afterward he gave $50,000 to a distant college, which was already rich, and claimed to be undenominational. As for the new D. D.'s, they all exerted themselves in our behalf, and raised for us a considerable sum of ready money. All told, these honorary degrees brought us in nearly $6,000, which, together with our student-fees, was all we had to sustain our university through its second college-year.

We are now just entering upon our third season of actual collegiate work, and troubles accumulate over us. Our money is gone, our students are deserting to other institutions, and, if we had not faith

in our grand enterprise the future would seem dark indeed. Some of the trustees advocate closing temporarily. Brother A—— has withdrawn from the board; Mr. Virtue refuses to do any thing more for us; our creditors are proving to be most inveterate duns, and no way seems to be open for going on. Still, we must go on; inaction would be fatal. Some rich friend ought to endow us liberally—a great university like ours cannot be permitted to die. In our two opening years we have done as much work as did either Yale or Harvard in the corresponding periods of their youth; why should we not rise as they have risen? We appeal to the public at large for support—to all friends of true education, of high culture, of moral civilization. Let it not be said in despotic Europe that Americans cared so little for intellectual advancement that they allowed their most promising university to fail. Let the rich give us money liberally for the glory of the denomination which we represent; others who cannot give should send us their sons and daughters to be educated in the true principles of life and the faith of the early fathers. No matter how dark the present may appear, the future is bright before us; great success must eventually attend our labors; unborn generations will one day look back and say, "Our ancestors sustained that university in its hour of trial, and have transmitted to us the inheritance of its greatness." Statesmen, poets, and chieftains, shall hail our university as their *alma mater*, and contribute gladly to its glory and its support.

THE WARFARE OF SCIENCE.[1]

By ANDREW D. WHITE, LL. D.,
PRESIDENT OF CORNELL UNIVERSITY.

II.

I PASS, now, to fields of more immediate importance to us—to Anatomy and Medicine.

It might be supposed that the votaries of sciences like these would be suffered to escape attack; unfortunately, they have had to stand in the thickest of the battle.

As far back as the latter part of the thirteenth century, Arnold de Villa Nova was a noted physician and chemist. The missile usual in such cases was hurled at him. He was charged with sorcery and dealings with the devil; he was excommunicated and driven from Spain.[1]

Such seemed the fate of men in that field who gained even a glimmer of new scientific truth. Even men like Cardan, and Paracelsus, and Porta, who yielded much to popular superstitions, were at once

[1] Draper, "Int. Dev. of Europe," p. 421. Whewell, "Hist. of the Induct. Sciences," vol. i., p. 235; vol. viii., p. 36. Frédault, "Hist. de la Médecine," vol. i., p. 204.

set upon if they ventured upon any other than the path which the Church thought sound—the insufficient path of Aristotelian investigation.

We have seen that the weapons used against the astronomers were mainly the epithets infidel and atheist. We have also seen that the missiles used against the chemists and physicians were the epithets "sorcerer" and "leaguer with the devil," and we have picked up on various battle-fields another effective weapon, the epithet "Mohammedan."

On the heads of the anatomists and physicians were concentrated *all* these missiles. The charge of atheism ripened into a proverb: "*Ubi sunt tres medici, ibi sunt duo athei.*"[1] Magic seemed so common a charge that many of the physicians seemed to believe it themselves. Mohammedanism and Averroism became almost synonymous with medicine, and Petrarch stigmatized Averroists as "men who deny Genesis and bark at Christ."[2]

Not to weary you with the details of earlier struggles, I will select a great benefactor of mankind and champion of scientific truth at the period of the Revival of Learning and the Reformation—Andreas Vesalius, the founder of the modern science of anatomy. The battle waged by this man is one of the glories of our race.[3]

The old methods were soon exhausted by his early fervor, and he sought to advance science by truly scientific means—by patient investigation and by careful recording of results.

From the outset Vesalius proved himself a master. In the search for real knowledge he braved the most terrible dangers. Before his time the dissection of the human subject was thought akin to sacrilege. Occasionally some anatomist, like Mundinus, had given some little display with such a subject; but, for purposes of *investigation*, such dissection was forbidden. Even such men in the early Church as Ter-

[1] Honorius III. forbade medicine to be practised by archdeacons, deacons, priests, etc. Innocent III. forbade surgical operations by priests, deacons, or sub-deacons. In 1243 Dominicans banished books on medicine from their monasteries. *See* Daunou cited by Buckle, "Posthumous Works," vol. ii., p. 567. For thoughtful and witty remarks on the struggle at a recent period, *see* Maury, "L'Ancienne Académie des Sciences," Paris, 1864, p. 148. Maury says: "La faculté n'aimait pas à avoir affaire aux théologiens qui procèdent par anathèmes beaucoup plus que par analyses."

[2] Renan, "Averroés et l'Averroisme," Paris, 1867, pp. 327, 333, 335. For a perfectly just statement of the only circumstances which can justify the charge of "atheism," *see* Dr. Deems's article in POPULAR SCIENCE MONTHLY, February, 1876.

[3] Whewell, vol. iii., p. 328, says, rather loosely, that Mundinus "dissected at Bologna in 1315." How different his idea of dissection was from that introduced by Vesalius, may be seen by Cuvier's careful statement that the entire number of dissections by Mundinus was three. The usual statement is that it is two. *See* Cuvier, "Hist. des Sci. Nat.," tome iii., p. 7; also, Sprengel, Frédault, and Hallam; also, Littré, "Médecine et Médecins," chap. on anatomy. For a very full statement of the agency of Mundinus in the progress of anatomy, *see* Portal, "Hist. de l'Anatomie et de la Chirurgérie," vol. i., pp. 209–216.

tullian and St. Augustine held anatomy in abhorrence.[1] Boniface VIII. interdicted dissection as sacrilege.[2]

Through this sacred conventionalism Vesalius broke without fear. Braving ecclesiastical censure and popular fury, he studied his science by the only method that could give useful results. No peril daunted him. To secure the material for his investigations, he haunted gibbets and charnel-houses; in this search he risked alike the fires of the Inquisition and the virus of the plague. First of all men he began to place the great science of human anatomy on its solid, modern foundations—on careful examination and observation of the human body. This was his first great sin, and it was soon aggravated by one considered even greater.

Perhaps the most unfortunate thing that has ever been done for Christianity is the tying it to forms of science which are doomed and gradually sinking. Just as in the time of Roger Bacon, excellent but mistaken men devoted all their energies to binding Christianity to Aristotle; just as in the time of Reuchlin and Erasmus, they insisted on binding Christianity to Thomas Aquinas—so in the time of Vesalius, such men made every effort to link Christianity to Galen.

The cry has been the same in all ages; it is the same which we hear in this age for curbing scientific studies—the cry for what is called "sound learning." Whether standing for Aristotle against Bacon, or Aquinas against Erasmus, or Galen against Vesalius, or making mechanical Greek verses at Eton instead of studying the handiwork of the Almighty, or reading Euripides with translations instead of Lessing and Goethe in the original, the cry always is for "sound learning." The idea always is that these studies are *safe*.

At twenty-eight years of age Vesalius gave to the world his great work on human anatomy. With it ended the old and began the new. Its researches, by their thoroughness, were a triumph of science; its illustrations, by their fidelity, were a triumph of art.

To shield himself as far as possible in the battle which he foresaw must come, Vesalius prefaced the work by a dedication to the Emperor Charles V. In this dedicatory preface he argues for his method, and against the parrot repetitions of the mediæval textbooks; he also condemns the wretched anatomical preparations and specimens made by physicians who utterly refused to advance beyond the ancient master.

The parrot-like repeaters of Galen gave battle at once. After the

[1] For Tertullian and Augustine against anatomical investigation, *see* Blount's "Essays," cited in Buckle's "Posthumous Works," vol. ii., pp. 107, 108. The passage from St. Augustine is in "Civ. Dei," xxii., p. 24. *See* Abbé Migne, "Patrologia," vol. xl., p. 791.

[2] For Boniface VIII. and his interdiction of dissections, *see* Buckle's "Posthumous Works," vol. ii., p. 567. For injurious effects of this ecclesiastical hostility to anatomy upon the development of art, *see* Woltman, "Holbein and His Time," pp. 266, 267. For an excellent statement of the true relation of the medical profession to religious questions, *see* Prof. Acland, "General Relations of Medicine in Modern Times," Oxford, 1868.

manner of their time, their first missiles were epithets; and, the almost infinite magazine of these having been exhausted, they began to use sharper weapons—weapons theologic.

At first the theologic weapons failed. A conference of divines having been asked to decide whether dissection of the human body is sacrilege, gave a decision in the negative. The reason is simple; Charles V. had made Vesalius his physician, and could not spare him. But, on the accession of Philip II. of Spain, the whole scene changed. That most bitter of bigots must of course detest the great innovator.

A new weapon was now forged. Vesalius was charged with dissecting living men,[1] and, either from direct persecution, as the great majority of authors assert, or from indirect influences, as the recent apologists for Philip II. allow, Vesalius became a wanderer. On a pilgrimage to the Holy Land to atone for his sin, he was shipwrecked, and in the prime of his life and strength he was lost to this world.

And yet not lost. In this century he again stands on earth. The painter Hamann has again given him to us. By the magic of Hamann's pencil, we look once more into Vesalius's cell. Its windows and doors, bolted and barred within, betoken the storm of bigotry which rages without; the crucifix, toward which he turns his eyes, symbolizes the spirit in which he labors. The corpse of the plague-stricken, over which he bends, ceases to be repulsive; his very soul seems to send forth rays from the canvas which strengthen us for the good fight in this age.[2]

He was hunted to death by men who conscientiously supposed that he was injuring religion. His poor, blind foes destroyed one of religion's greatest apostles. What was his influence on religion? He substituted for repetition, by rote, of worn-out theories of dead men, conscientious and reverent searching into the works of the living God. He substituted for representations of the human structure—pitiful and unreal—truthful representations, revealing the Creator's power and goodness in every line.[3]

I hasten now to the most singular struggle and victory of medical science between the sixteenth and nineteenth centuries.

Early in the last century, Boyer presented Inoculation as a preventive of small-pox, in France; thoughtful physicians in England, led by Lady Montagu and Maitland, followed his example.

Theology took fright at once on both sides of the Channel. The

[1] For a similar charge against anatomical investigations at a much earlier period, *see* Littré, "Médecine et Médecins," chapter on anatomy.

[2] The original painting of Vesalius at work in his cell, by Hamann, is now at Cornell University.

[3] For a curious example of weapons drawn from Galen and used against Vesalius, *see* Lewes, "Life of Goethe," p. 343, note. For proofs that I have not over-estimated Vesalius, *see* Portal, *ubi supra*. Portal speaks of him as "*le génie le plus droit qu'eut l'Europe*," and again, "*Vesale me paraît un des plus grands hommes qui ait existé.*"

French theologians of the Sorbonne solemnly condemned the practice. English theologians were most loudly represented by the Rev. Edward Massy, who, in 1722, preached a sermon in which he declared that Job's distemper was probably confluent small-pox, and that he had been doubtless inoculated by the devil—that diseases are sent by Providence for the punishment of sin, and that the proposed attempt to prevent them is "a diabolical operation." This sermon was entitled "The Dangerous and Sinful Practice of Inoculation." Not less absurd was the sermon of the Rev. Mr. Delafaye, entitled "Inoculation an Indefensible Practice." Thirty years later the struggle was still going on. It is a pleasure to note one great churchman, Maddox, Bishop of Worcester, giving battle on the side of right reason; but as late as 1753 we have the Rector of Canterbury denouncing inoculation from his pulpit in the primatial city, and many of his brethren following his example. Among the most common weapons hurled by churchmen at the supporters of inoculation, during all this long war, were charges of sorcery and atheism.[1]

Nor did Jenner's blessed discovery of Vaccination escape opposition on similar grounds. In 1798 an anti-vaccine society was formed by clergymen and physicians, calling on the people of England to suppress vaccination as "bidding defiance to Heaven itself—even to the will of God"—and declaring that "the law of God prohibits the practice." In 1803 the Rev. Dr. Ramsden thundered against it in a sermon before the University of Cambridge, mingling texts of Scripture with calumnies against Jenner; but Plumptre in England, Waterhouse in America, and a host of other good men and true, press forward to Jenner's side, and at last science, humanity, and right reason, gain the victory.[2]

But I pass to one typical conflict in our days. In 1847 James Young Simpson, a Scotch physician of eminence, advocated the use of Anæsthetics in obstetrical cases.

Immediately a storm arose. From pulpit after pulpit such a use of chloroform was denounced as impious. It was declared contrary to Holy Writ, and texts were cited abundantly. The ordinary declaration was, that to use chloroform was "to avoid one part of the primeval curse on woman."[3]

[1] *See* Sprengel, "Histoire de la Médecine," vol. vi., pp. 39–80. For the opposition of the Paris Faculty of Theology to inoculation, *see* the "Journal de Barbier," vol. vi., p. 294. For bitter denunciations of the inoculation by English clergy, and for the noble stand against them by Maddox, *see* Baron, "Life of Jenner," vol. i., pp. 231, 232, and vol. ii., pp. 39, 40. For the strenuous opposition of the same clergy, *see* Weld, "History of the Royal Society," vol. i., p. 464, note. Also, for the comical side of this matter, *see* Nichols's "Literary Illustrations," vol. v., p. 800.

[2] For the opposition of conscientious men in England to vaccination, *see* Duns, "Life of Sir James Y. Simpson, Bart.," London, 1873, pp. 248, 249; also Baron, "Life of Jenner," *ubi supra*, and vol. ii., p. 43; also "Works of Sir J. Y. Simpson," vol. ii.

[3] *See* Duns, "Life of Sir J. Y. Simpson," pp. 215–222.

Simpson wrote pamphlet after pamphlet to defend the blessing which he brought into use; but the battle seemed about to be lost, when he seized a new weapon. "My opponents forget," said he, "the twenty-first verse of the second chapter of Genesis. That is the record of the first surgical operation ever performed, and that text proves that the Maker of the universe, before he took the rib from Adam's side for the creation of Eve, caused a deep sleep to fall on Adam."

This was a stunning blow; but it did not entirely kill the opposition. They had strength left to maintain that "the deep sleep of Adam took place before the introduction of pain into the world—in the state of innocence."[1] But now a new champion intervened—Thomas Chalmers. With a few pungent arguments he scattered the enemy forever, and the greatest battle of science against suffering was won.[2]

But was not the victory won also for religion? Go to yonder monument, in Boston, to one of the discoverers of anæsthesia. Read this inscription from our sacred volume: "This also cometh from the Lord of hosts which is wonderful in counsel and excellent in working."

I now ask you to look at another part of the great warfare, and I select it because it shows more clearly than any other how Protestant nations, and in our own time, have suffered themselves to be led into the same errors that have wrought injury to religion and science in other times. We will look very briefly at the battle-fields of Geology.

From the first lispings of this science there was war. The prevailing doctrine of the Church was, that "in the beginning God made the heavens and the earth," that "all things were made at the beginning of the world," and that to say that stones and fossils have been made since "the beginning," is contrary to Scripture. The theological substitutes for scientific explanations ripened into such as these—that the fossils are "sports of Nature," or "creations of plastic force," or "results of a seminal air acting upon rocks," or "models" made by the Creator before he had fully decided upon the best manner of creating various beings. But, while some latitude was allowed among these theologico-scientific explanations, it was held essential to believe that they were placed in all the strata, on one of the creation-days, by the hand of the Almighty; and that this was done for some mysterious purpose of his own, probably for the trial of human faith.

In the sixteenth century Fracastoro and Palissy broached the true idea, but produced little effect. Near the beginning of the seventeenth century De Clave, Bitaud, and De Villon, revived it; straightway the Theologic Faculty of Paris protested against the doctrine as unscriptural, destroyed the offending treatises, banished the authors

[1] *See* Duns, "Life of Sir J. Y. Simpson," pp. 256–259.

[2] "Ibid.," p. 260; also "Works of Sir J. Y. Simpson," *ubi supra*.

from Paris, and forbade them to live in towns or enter places of public resort.[1]

At the middle of the eighteenth century, Buffon made another attempt to state simple and fundamental geological truths. The theological faculty of the Sorbonne immediately dragged him from his high position, forced him to recant ignominiously and to print his recantation.

It required a hundred and fifty years for Science to carry the day fairly against this single preposterous theory. The champion who dealt it the deadly blow was Scilla, and his weapons were facts revealed by the fossils of Calabria.

But the advocates of tampering with scientific reasoning now retired to a new position. It was strong, for it was apparently based on Scripture, though, as the whole world now knows, an utterly false interpretation of Scripture. The new position was that the fossils were produced by the deluge of Noah.

In vain had it been shown, by such devoted Christians as Bernard Palissy, that this theory was utterly untenable; in vain did good men protest against the injury sure to result to religion by tying it to a scientific theory sure to be exploded: the doctrine that fossils were the remains of animals drowned at the flood continued to be upheld by the great majority as "sound doctrine," and as a blessed means of reconciling science with Scripture.[2]

To sustain this "scriptural view," so called, efforts were put forth absolutely herculean, both by Catholics and Protestants. Mazurier declared certain fossil remains of a mammoth, discovered in France, to be bones of giants mentioned in Scripture. Father Torrubia did the same thing in Spain. Increase Mather sent similar remains, discovered in America, to England, with a similar statement. Scheuchzer made parade of the bones of a great lizard discovered in Germany, as the *homo diluvii testis*, the fossil man, proving the reality of the deluge.[3]

In the midst of this appears an episode very comical but very instructive; for it shows that the attempt to shape the deductions of science to meet the exigencies of theology may mislead heterodoxy as absurdly as orthodoxy.

[1] Morley, "Life of Palissy the Potter," vol. ii., p. 315, *et seq.*

[2] Audiat, "Vie de Palissy," p. 412. Cantu, "Hist. Universelle," vol. xv., p. 492.

[3] For ancient beliefs regarding giants, *see* Leopardi, "Saggio sopra gli errori popolari," etc., chapter xv. For accounts of the views of Mazurier and Scheuchzer, *see* Büchner, "Man in Past, Present, and Future," English translation, pp. 235, 236. For Increase Mather's views, *see* "Philosophical Transactions," xxiv., 85. For similar fossils sent from New York to the Royal Society as remains of giants, *see* Weld, "History of the Royal Society," vol. i., p. 421. For Father Torrubia and his *Gigantologia Española*, *see* D'Archiac, "Introduction à l'Etude de la Paléontologie stratiographique," Paris, 1864, p. 202. For admirable summaries, *see* Lyell, "Principles of Geology," London, 1867; D'Archiac, "Géologie et Paléontologie," Paris, 1866; Pictet, "Traité de Paléontologie," Paris, 1853; Vezian, "Prodrome de la Géologie," Paris, 1863; Haeckel, "History of Creation," New York, 1876, chapter iii.

About the year 1760 news of the discovery of marine fossils in various elevated districts of Europe reached Voltaire. He too had a theologic system to support, though his system was opposed to that of the sacred books of the Hebrews. He feared that these new discoveries might be used to support the Mosaic accounts of the Deluge. All his wisdom and wit, therefore, were compacted into arguments to prove that the fossil fishes were remains of fishes intended for food, but spoiled and thrown away by travelers; that the fossil shells were accidentally dropped by Crusaders and pilgrims returning from the Holy Land; and that the fossil bones of a hippopotamus found between Paris and Étampes were parts of a skeleton belonging to the cabinet of some ancient philosopher. Through chapter after chapter Voltaire, obeying the supposed necessities of his theology, fights desperately the growing results of the geologic investigations of his time.[1]

But far more wide-spread and disastrous was the effort on the other side to show that the fossils were caused by the Deluge of Noah.

No supposition was too violent to support a theory which was considered vital to the Bible. Sometimes it was claimed that the tail of a comet had produced the deluge. Sometimes, by a prosaic rendering of the expression regarding the breaking up of the fountains of the great deep, a theory was started that the earth contained a great cistern, from which the waters came and to which they retired. By taking sacred poetry as prose, and by giving a literal interpretation of it, Thomas Burnet in his "Sacred Theory of the Earth," Whiston in his "Theory of the Deluge," and others like them, built up systems which bear to real geology much the same relation that the "Christian Topography" of Cosmas bears to real geography. In vain were exhibited the absolute geological, zoölogical, and astronomical proofs that no universal deluge, or deluge covering any great extent of the earth, had taken place within the last six thousand or sixty thousand years; in vain did Bishop Clayton declare that the deluge could not have taken place save in that district where Noah lived before the flood; in vain was it shown that, even if there had been a universal deluge, the fossils were not produced by it; the only answers were the citation of the text—"and all the high mountains which were under the whole heaven were covered"—and denunciation of infidelity. In England, France, and Germany, belief that the fossils were produced by the Deluge of Noah was insisted upon as part of that faith essential to salvation.[2] It took a hundred and twenty

[1] *See* Voltaire, "Dissertation sur les Changements arrivés dans notre Globe," also Voltaire, "Les Singularités de la Nature," chapter xii., near close of vol. v. of the Didot edition of 1843; also Jevons, "Principles of Science," vol. ii., p. 328.

[2] For a candid summary of the proofs from geology, astronomy, and zoölogy, that the Noachian Deluge was not universally or widely extended, *see* McClintock and Strong, "Cyclopædia of Biblical Theology and Ecclesiastical Literature," article "Deluge." For general history *see* Lyell, D'Archiac, and Vezian. For special cases showing bitterness of the conflict, *see* the Rev. Mr. Davis's "Life of Rev. Dr. Pye Smith," *passim*.

years for the searchers of God's truth, as revealed in Nature—such men as Buffon, Linnæus, Whitehurst, and Daubenton—to push their works under these mighty fabrics of error, and, by statements which could not be resisted, to explode them.

Strange as it may at first seem, the war on geology was waged more fiercely in Protestant countries than in Catholic; and, of all countries, England furnished the most bitter opponents to geology at first, and the most active negotiators in patching up a truce on a basis of sham science afterward.[1]

You have noted already that there are, generally, two sorts of attack on a new science. First, there is the attack by pitting against science some great doctrine in theology. You saw this in astronomy, when Bellarmin and others insisted that the doctrine of the earth revolving about the sun is contrary to the doctrine of the incarnation. So now, against geology, it was urged that the scientific doctrine that the fossils represented animals which died before Adam, was contrary to the doctrine of Adam's fall and that "death entered the world by sin."

Then there is the attack by literal interpretation of texts, which serves a better purpose generally in rousing prejudices.

It is difficult to realize it now, but within the memory of many of us the battle was raging most fiercely in England, and both these kinds of artillery were in full play and filling the civilized world with their roar.

About thirty years ago the Rev. J. Mellor Brown, the Rev. Henry Cole, and others, were hurling at all geologists alike, and especially at such Christian divines as Dr. Buckland, and Dean Conybeare, and Pye Smith, and such religious scholars as Prof. Sedgwick, the epithets of "infidel," "impugner of the sacred record," and "assailant of the volume of God."

Their favorite weapon was the charge that these men were "attacking the truth of God," forgetting that they were simply opposing the mistaken interpretations of Messrs. Brown, Cole, and others like them, inadequately informed.

They declared geology "not a subject of lawful inquiry," denouncing it as "a dark art," as "dangerous and disreputable," as "a forbidden province," as "infernal artillery," and as "an awful evasion of the testimony of revelation."[2]

This attempt to scare men from the science having failed, various other means were taken. To say nothing about England, it is humiliating to human nature to remember the annoyances, and even trials, to which the pettiest and narrowest of men subjected such Christian

[1] For a philosophical statement of reasons why the struggle was more bitter, and the attempt at deceptive compromises more absurd in England than elsewhere, *see* Maury, "L'Ancienne Académie des Sciences," second edition, p. 152.

[2] *See* Pye Smith, D. D., "Geology and Scripture," pp. 156, 157, 168, 169.

scholars in our own country as Benjamin Silliman and Edward Hitchcock and Louis Agassiz.

But it is a duty and a pleasure to state here that one great Christian scholar did honor to religion and to himself by standing up for the claims of science, despite all these clamors. That man was Nicholas Wiseman, better known afterward as Cardinal Wiseman. The conduct of this pillar of the Roman Catholic Church contrasts nobly with that of timid Protestants who were filling England with shrieks and denunciations.[1]

And here let me note that one of the prettiest skirmishes in this war was made in New England. Prof. Stuart, of Andover, justly honored as a Hebrew scholar, virtually declared that geology was becoming dangerous; that to speak of six periods of time for the creation was flying in the face of Scripture; that Genesis expressly speaks of six days, each made up of an evening and a morning, and not six periods of time.

To him replied a professor in Yale College, James Kingsley. In an article admirable for keen wit and kindly temper, he showed that Genesis speaks just as clearly of a solid firmament as of six ordinary days, and that if Prof. Stuart had got over one difficulty and accepted the Copernican theory, he might as well get over another and accept the revelations of geology. The encounter was quick and decisive, and the victory was with science and our own honored Yale.[2]

But perhaps the most singular attempt against geology was made by a fine specimen of the English Don—Dean Cockburn, of York—to *scold* its champions out of the field. Without, apparently, the simplest elementary knowledge of geology, he opened a battery of abuse. He gave it to the world at large, by pulpit and press; he even inflicted it upon leading statesmen by private letters.[3]

From his pulpit in York Minster, Mary Somerville was denounced coarsely, by name, for those studies in physical geography which have made her honored throughout the world.[4]

But these weapons did not succeed. They were like Chinese gongs and dragon-lanterns against rifled cannon. Buckland, Pye

[1] Wiseman, "Twelve Lectures on the Connection between Science and Revealed Religion," first American edition, New York, 1837.

[2] *See Silliman's Journal*, vol. xxx., p. 114.

[3] Prof. Goldwin Smith informs me that the papers of Sir Robert Peel, yet unpublished, contain very curious specimens of these epistles.

[4] *See* "Personal Recollections of Mary Somerville," Boston, 1874, pp. 139 and 375. Compare with any statement of his religious views that Dean Cockburn was able to make, the following from Mrs. Somerville: "Nothing has afforded me so convincing a proof of the Deity as these purely mental conceptions of numerical and mathematical science which have been, by slow degrees, vouchsafed to man—and are still granted in these latter times, by the differential calculus, now superseded by the higher algebra—all of which must have existed in that sublimely omniscient mind from eternity."—*See* "Personal Recollections," pp. 140, 141.

Smith, Lyell, Silliman, Hitchcock, Murchison, Agassiz, Dana, and a host of noble champions besides, press on, and the battle for truth is won.

And was it won merely for men of science? The whole civilized world declares that it was won for religion—that thereby was infinitely increased the knowledge of the power and goodness of God.

Did time permit, we might go over other battle-fields no less instructive than those we have seen. We might go over the battle-fields of Agricultural Progress, and note how, by a most curious perversion of a text of Scripture, great masses of the peasantry of Russia were prevented from raising and eating potatoes,[1] and how in Scotland at the beginning of this century the use of fanning-mills for winnowing grain was denounced as contrary to the text "the wind bloweth where it listeth," etc., as leaguing with Satan, who is "prince of the powers of the air," and as sufficient cause for excommunication from the Scotch Church.[2]

We might go over the battle-fields of Industrial Science, and note how the introduction of railways into France was declared, by the Archbishop of Besançon, an evidence of the divine displeasure against country innkeepers who set meat before their guests on fast-days, and now were punished by seeing travelers carried by their doors; and how railroad and telegraph were denounced from a noted pulpit as "heralds of Antichrist." And then we might pass to Protestant England and recall the sermon of the Curate of Rotherhithe at the breaking in of the Thames Tunnel, so destructive to life and property, declaring that "it was but a just judgment upon the presumptuous aspirations of mortal man."[3]

We might go over the battle-fields of Ethnology and note how a few years since an honored American investigator, proposing in a learned society the discussion of the question between the origin of the human race from a single pair and from many pairs, was called to order and silenced as atheistic, by a Protestant divine whose memory is justly dear to thousands of us.[4]

Interesting would it be to look over the field of Meteorology—beginning with the conception, supposed to be scriptural, of angels opening and shutting "the windows of heaven" and letting out "the waters that be above the firmament" upon the earth—continuing

[1] *See* Haxthausen, "Études sur la Russie."

[2] Burton, "History of Scotland," vol. viii., p. 511. *See* also Mause Headrigg's views in Scott's "Old Mortality," chapter vii. For the case of a person debarred from the communion for "raising the devil's wind" with a winnowing-machine, *see* works of Sir J. Y. Simpson, vol. ii. Those doubting the authority or motives of Simpson may be reminded that he was, to the day of his death, one of the strictest adherents of Scotch orthodoxy.

[3] *See* Journal of Sir I. Brunel, for May 20, 1827, in "Life of I. K. Brunel," p. 30.

[4] This scene will be recalled, easily, by many leading ethnologists in America, and especially by Mr. E. G. Squier, formerly minister of the United States to Central America.

through the battle of Fromundus and Bodin, down to the onslaught upon Lecky, in our own time, for drawing a logical and scientific conclusion from the doctrine that Meteorology is obedient to laws.[1]

We might go over the battle-fields of Cartography and see how at one period, on account of expressions in Ezekiel, any map of the world which did not place Jerusalem in the centre, was looked on as impious.[2]

We might go over the battle-fields of Political Economy and note how a too literal interpretation of scriptural texts regarding taking interest for money wrought fearful injury, not only to the material interests, but also to the moral character of hosts of enterprising and thrifty men, during ages.[3]

We might go over the battle-fields of Social Science in Protestant countries, and note the opposition of conscientious men to the taking of the census, in Sweden and in the United States, on account of the terms in which the numbering of Israel is spoken of in the Old Testament.[4]

And we might also see how, on similar grounds, religious scruples have been avowed against so beneficial a thing as Life Insurance.[5]

I now come to the warfare on Scientific Instruction. I shall not take time for a sketch of the earlier phases of this warfare, but shall simply present a few typical conflicts that have occurred within the last ten years.

During the years 1867 and 1868 war was commenced against certain leading professors of the Medical School of Paris, especially against Profs. Vulpian and See, and against the Department of Pub-

[1] The meteorological battle is hardly fought out yet. Many excellent men seem still to entertain views almost identical with those of over two thousand years ago, depicted in "The Clouds" of Aristophanes.

[2] These texts are Ezekiel v. 5 and xxxviii. 12. The progress of geographical knowledge, evidently, caused them to be softened down somewhat in our King James's version; but the first of them reads, in the Vulgate, "Ista est Hierusalem, in medio gentium posui eam et in circuitu ejus terras;" and the second reads in the Vulgate "in medio terræ," and in the Septuagint ἐπὶ τὸν ὀμφαλὸν τῆς γῆς. That the literal centre of the earth was meant, *see* proof in St. Jerome, Commentar. in Ezekiel, lib. ii., and for general proof, *see* Leopardi, "Saggio sopra gli errori popolari degli antichi," pp. 207, 208. For an idea of orthodox geography in the middle ages, *see* Wright's "Essay on Archæology," vol. ii., chapter "On the Map of the World in Hereford Cathedral."

[3] For a very complete history of this opposition of the Church to one of the fundamental doctrines of political economy, *see* Murray, "History of Usury," Philadelphia, 1866; also, Lecky, "History of Rationalism," vol. ii., chapter vi. For collateral information as to effect of similar doctrines on Venetian commerce, *see* Lindsay, "History of Merchant Shipping," London, 1874, vol. ii.

[4] *See* Michaelis, "Commentaries on the Laws of Moses," 1874, vol. ii., p. 3. The writer of the present article himself witnessed the reluctance of a very conscientious man to answer the questions of a census marshal, Mr. Lewis Hawley, of Syracuse, N. Y., and this reluctance was based upon the reasons assigned in II. Samuel, chapter xxiv. 1, and I. Chronicles, chapter xxi. 1, for the numbering of the children of Israel.

[5] *See* De Morgan, "Paradoxes," pp. 214–220.

lic Instruction, having at its head the Minister of State, Duruy. The storming party in the French Senate was led by a venerable and conscientious prelate, Cardinal de Bonnechose.

It was charged by Monseigneur de Bonnechose and his party, that the tendencies of the teachings of these professors were fatal to religion and morality. A heavy artillery of phrases was hurled, such as "sapping the foundations," etc., "breaking down the bulwarks," etc., etc., and withal a new missile was used with much effect, the epithet of "materialist."

The result can be easily guessed. Crowds came to the lecture-rooms of these professors, and the lecture-room of Prof. See, the chief offender, was crowded to suffocation.

A siege was begun in due form. A young physician was sent by the cardinal's party into the heterodox camp as a spy. Having heard one lecture of Prof. See, he returned with information that seemed to promise easy victory to the besieging party. He brought a terrible statement, one that seemed enough to overwhelm See, Vulpian, Duruy, and the whole hated system of public instruction in France.

Good Cardinal Bonnechose seized the tremendous weapon. Rising in his place in the Senate he launched a most eloquent invective against the Minister of State who could protect such a fortress of impiety as the College of Medicine; and, as a climax, he asserted, on the evidence of his spy fresh from Prof. See's lecture-room, that the professor had declared, in his lecture of the day before, that so long as he had the honor to hold his professorship he would combat the false idea of the existence of the soul (*idée de l'ame*). The weapon seemed resistless, and the wound fatal; but M. Duruy rose and asked to be heard.

His statement was simply that he held in his hand documentary proofs that Prof. See never made such a declaration. He held the notes used by Prof. See in his lecture. Prof. See, it appeared, belonged to a school in medical science which combated the idea of an art (*idée d'un art*) in medicine. The real expression used was *l'idée d'un art* —the idea of an *art;* the expression which the imagination of the cardinal's eager emissary made of it was *l'idée d'une ame*—the idea of a *soul.*

The forces of the enemy were immediately turned. They retreated in confusion amid the laughter of all France; and a well-meant attempt to check what was feared might be dangerous in science simply ended in bringing ridicule on religion, and thrusting still deeper into the minds of thousands of men that most mistaken of all mistaken ideas—the conviction that religion and science are enemies.[1]

[1] For general account of the Vulpian and See matter, *see Revue des Deux Mondes*, 31 Mai, 1868. "Chronique de la Quinzaine," pp. 763–765. As to the result on popular thought may be noted the following comment on the affair by the *Revue* which is as free as possible from any thing like rabid anti-ecclesiastical ideas: "*Elle a été vraiment curieuse, instructive, assez triste et même un peu amusante.*"

But justice forbids our raising an outcry against Roman Catholicism alone for this. In 1864 a number of excellent men in England drew up a declaration to be signed by students in the natural sciences, expressing "sincere regret that researches into scientific truth are perverted by some in our time into occasion for casting doubt upon the truth and authenticity of the Holy Scriptures." Nine-tenths of the leading scientific men of England refused to sign it. Nor was this the worst. Sir John Herschel, Sir John Bowring, and Sir W. R. Hamilton, administered, through the press, castigations which roused general indignation against the proposers of the circular, and Prof. De Morgan, by a parody, covered memorial and memorialists with ridicule. It was the old mistake, and the old result followed in the minds of multitudes of thoughtful young men.[1]

And in yet another Protestant country this same wretched mistake was made. In 1868, several excellent Churchmen in Prussia thought it their duty to meet for the denunciation of "Science falsely so called." Two results followed. Upon the great majority of these really self-sacrificing men—whose first utterances showed crass ignorance of the theories they attacked—there came quiet and wide-spread contempt; upon Pastor Knak, who stood forth and proclaimed views of the universe which he thought scriptural, but which most schoolboys knew to be childish, came a burst of good-natured derision from every quarter of the German nation.[2]

Warfare of this sort against Science seems petty indeed; but it is to be guarded against in Protestant countries not less than Catholic; it breaks out in America not less than in Europe. I might exhibit many proofs of this. Do conscientious Roman bishops in France labor to keep all advanced scientific instruction under their own control—in their own universities and colleges; so do very many not less conscientious Protestant clergymen in our own country insist that advanced education in science and literature shall be kept under control of their own sectarian universities and colleges, wretchedly one-sided in their development, and miserably inadequate in their equipment: did a leading Spanish university, until a recent period, exclude professors holding the Newtonian theory; so does a leading American college exclude professors holding the Darwinian theory: have Catholic colleges in Italy rejected excellent candidates for professorships on account of "unsafe" views regarding the Immaculate Conception; so are Protestant colleges in America every day rejecting excellent candidates on account of "unsafe" views regarding the Apostolic Succession, or the Incarnation, or Baptism, or the Perseverance of the Saints.

And how has all this system resulted. In the older nations, by a natural reaction, these colleges under strict ecclesiastical control

[1] De Morgan, "Paradoxes," pp. 421–428; also Daubeny's "Essays."

[2] *See* the Berlin newspapers for the summer of 1868, especially *Kladderadatsch*.

have sent forth the most bitter enemies the Christian Church has ever known—of whom Voltaire and Renan and St. Beuve are types; and there are many signs that the same causes are producing the same result in our own country.

I might allude to another battle-field in our own land and time. I might show how an attempt to meet the great want, in the State of New York, of an institution providing scientific instruction, has been met with loud outcries from many excellent men, who fear injury thereby to religion. I might picture to you the strategy which has been used to keep earnest young men from an institution, which, it is declared, cannot be Christian because it is not sectarian. I might lay before you wonderful lines of argument which have been made, to show the dangerous tendencies of a plan which gives to scientific studies the same weight as to classical studies, and which lays no less stress on modern history and literature than on ancient history and literature.

I might show how it has been denounced by the friends and agents of denominational colleges and in many sectarian journals, how the most preposterous charges have been made and believed by good men, how the epithets of "godless," "infidel," "irreligious," "unreligious," "atheistic," have been hurled against a body of Christian trustees, professors, and students, and with little practical result save arousing a suspicion in the minds of large bodies of thoughtful young men, that the churches dread scientific studies untrammeled by sectarianism.

You have now gone over the greater struggles in the long war between Ecclesiasticism and Science, and have glanced at the lesser fields. You have seen the conflicts in Physical Geography, as to the form of the earth; in Astronomy, as to the place of the earth in the universe; in Chemistry and Physics; in Anatomy and Medicine; in Geology; in Meteorology: in Cartography; in the Industrial and Agricultural Sciences; in Political Economy and Social Science; and in Scientific Instruction.

In every case, whether the war has been long or short, forcible or feeble, you have seen this same result—Science has at last gained the victory.

In every case too, you have seen that while this ecclesiastical war, during its continuance, has tended to drive multitudes of thoughtful men away from religion, the triumph of science has been a blessing to religion—ennobling its conceptions and bettering its methods.

May we not, then, hope that the greatest and best men in the Church, the men standing at centres of thought, will insist with power, more and more, that religion be no longer tied to so injurious a policy as that which this warfare reveals; that searchers for truth, whether in theology or natural science, work on as friends, sure that,

no matter how much at variance they may at times seem to be, the truths they reach shall finally be fused into each other?

No one needs fear the result. No matter whether Science shall complete her demonstration that man has been on the earth not merely six thousand years, or six millions of years; no matter whether she reveals new ideas of the Creator or startling relations between his creatures; no matter how many more gyves and clamps upon the spirit of Christianity she destroys, the result, when fully thought out, will serve and strengthen religion not less than science.[1]

The very finger of the Almighty has written on history that science must be studied by means proper to itself, and in no other way. That history is before us all. No one can gainsay it. It is decisive, for it is this: There has never been a scientific theory framed from the use of scriptural texts, wholly or partially, which has been made to stand. Such attempts have only subjected their authors to derision, and Christianity to suspicion. From Cosmas finding his plan of the universe in the Jewish tabernacle, to Increase Mather sending mastodon's bones to England as the remains of giants mentioned in Scripture; from Bellarmin declaring that the sun cannot be the centre of the universe, because such an idea vitiates the whole scriptural plan of salvation, to a recent writer declaring that an evolution theory cannot be true, because St. Paul says that "all flesh is not the same flesh," the result has always been the same.[2]

[1] In an eloquent sermon, preached in March, 1874, Bishop Cummins said, in substance: "The Church has no fear of Science; the persecution of Galileo was entirely unwarrantable; but Christians should resist to the last Darwinism; for that is evidently contrary to Scripture." The bishop forgets that Galileo's doctrine seemed to such colossal minds as Bellarmin, and Luther, and Bossuet, "evidently contrary to Scripture." Far more logical, modest, sagacious, and full of faith, is the attitude taken by his former associate, Dr. John Cotton Smith. "For geology, physiology, and historical criticism, have threatened or destroyed only particular forms of religious opinion; while they have set the spirit of religion free to keep pace with the larger generalizations of modern knowledge."—(PICTON, "The Mystery of Matter," London, 1873, p. 72.)

[2] In the *Church Journal*, New York, May 28, 1874, a reviewer praising Rev. Dr. Hodge's book against Darwinism, says: "Darwinism, whether Darwin knows it or not, whether the clergy, who are half prepared to accept it in blind fright as 'science,' know it or not, is a denial of every article of the Christian faith. It is supreme folly to talk as some do about accommodating Christianity to Darwinism. Either those who so talk do not understand Christianity, or they do not understand Darwinism. If we have all, men and monkeys, women and baboons, oysters and eagles, all 'developed' from an original monad and germ, then St. Paul's grand deliverance—'All flesh is not the same flesh. There is one kind of flesh of men, another of beasts, another of fishes, and another of birds. There are bodies celestial and bodies terrestrial'—may be still very grand in our funeral-service, but very untrue to fact." This is the same dangerous line of argument which Caccini indulged in in Galileo's time. Dangerous, for suppose "Darwinism" *be proved true!* For a soothing potion by a skillful hand, *see* Whewell on the consistency of evolution doctrines with teleological ideas; also Rev. Samuel Houghton, F. R. S., "Principles of Animal Mechanics," London, 1873, preface and page 156, for some interesting ideas on teleological evolution.

Such facts show that the sacred books of the world were not given for any such purpose as that to which so many men have endeavored to wrest them.[1]

Such facts show, too, that scientific hypotheses will be established or refuted by scientific men and scientific methods alone, and that no conscientious citation of texts or outcries as to consequences of scientific truths, from any other quarter, can do any thing save retard truth and cause needless anxiety.[2]

Is skepticism feared? All history shows that the only skepticism which does permanent harm is skepticism as to the value and safety of truth as truth. No skepticism has proved so corrosive to religion, none so cancerous in the human brain and heart.

Is faith cherished? All history shows that the first article of a saving faith, for any land or time, is faith that there is a Power in this universe strong enough to make truth-seeking safe, and good enough to make truth-telling useful.

What Science can do for the world is shown, not by those who have labored to concoct palatable mixtures of theology and science —men like Cosmas, and Torrubia, and Burnet, and Whiston—but by men who have fought the good fight of faith in truth for truth's sake —men like Roger Bacon, and Vesalius, and Palissy, and Galileo.

What Christianity can do for the world is shown, not by men who have stood on the high places screaming in wrath at the advance of science—not by men who have retreated in terror into the sacred caves and refused to look out upon the universe as it is, but by men who have preached and practised the righteousness of the prophets, and the aspirations of the Psalmist, and the blessed Sermon on the Mount, and "the first great commandment and the second which is like unto it," and St. James's definition of "pure religion and undefiled."

It is shown in the Roman Church, not by Tostatus and Bellarmin, but by St. Carlo Borromeo, and St. Vincent de Paul, and Fénelon, and Eugénie de Guérin; in the Anglican Church, not by Dean Cockburn, but by Howard, and Jenner, and Wilberforce, and Florence Nightingale; in the German Church, not by Pastor Knak, but by Pastor Harms; in the American Church, not by the Mathers and Stuarts, but by such as Bishop Whatcoat, and Channing, and Muhlenberg, and Father De Smet, and Samuel May, and Harriet Stowe.

Let the warfare of science, then, be changed. Let it be a warfare in which Religion and Science shall stand together as allies, not against each other as enemies. Let the fight be for truth of every

[1] To all who are inclined to draw scientific conclusions from biblical texts, may be commended the advice of a good old German divine of the Reformation period: "Seeking the milk of the Word, do not press the teats of Holy Writ too hard."

[2] For some excellent remarks on the futility of such attempts and outcries, *see* the Rev. Dr. Deems, in POPULAR SCIENCE MONTHLY for February, 1876.

kind against falsehood of every kind—for justice against injustice—for right against wrong—for the living kernel of religion rather than the dead and dried husks of sect and dogma; and the great powers whose warfare has brought so many sufferings shall at last join in ministering through earth God's richest blessings.

ON FALLACIES OF TESTIMONY RESPECTING THE SUPERNATURAL.

By WILLIAM B. CARPENTER, LL.D., F.R.S.

NO one who has studied the history of science can fail to recognize the fact that the rate of its progress has been in great degree commensurate with the degree of *freedom from any kind of prepossession* with which scientific inquiry has been conducted. And the chapters of Lord Bacon's "Novum Organum," in which he analyzes and classifies the prejudices that are apt to divert the scientific inquirer from his single-minded pursuit of truth, have rightly been accounted among the most valuable portions of that immortal work. To use the felicitous language of Dr. Thomas Brown, "the temple which Lord Bacon purified was not that of Nature herself, but the temple of the mind; in its innermost sanctuaries were the idols which he overthrew; and it was not till these were removed, that Truth would deign to unveil herself to adoration."

Every one, again, who watches the course of educated thought at the present time, must see that it is tending toward the exercise of that trained and organized common-sense which we call "scientific method," on subjects to which it is legitimately applicable within the sphere of religious inquiry. Science has been progressively, and in various ways, undermining the old "bases of belief;" and men in almost every religious denomination, animated by no spirit but that of reverent loyalty to truth, are now seriously asking themselves, whether the whole fabric of what is commonly regarded as authoritative revelation must not be carefully reëxamined under the searching light of modern criticism, in order that what is sound may be preserved and strengthened, and that the insecurity of some parts may not destroy the stability of the whole.

I notice, further, among even "orthodox" theologians of the present time, indications of a disposition to regard the New Testament miracles rather as incumbrances, than as props, to what is essential in Christianity; of a feeling that they are rather to be explained away,[1] than adduced as authoritative attestations of the teachings of

[1] Thus theologians of the "philosophic" school argue that miracles are not to be regarded as departures from the divine order, but are parts of the order originally settled

Jesus; and of a perception that to attempt to enforce a belief in them, on the part of the rising generation, will be either to alienate from the acceptance of those teachings many of the most cultured and most earnest young people of our time, or to reduce their minds to that state of unreasoning subservience to authority which finds its only logical basis in the Roman Catholic Church. And, moreover, I observe it to be among those, in various religious denominations, who are converging to the conclusion that the "authority" of Christianity most surely consists in the direct appeal it makes to the hearts and consciences of mankind, who most fully recognize in the life, teaching, and death of Christ, that manifestation of the Divine (*ἀπαύγασμα τῆς δόξης καὶ χαρακτὴρ τῆς ὑποστάσεως αὐτοῦ*[1]) which constitutes him their Master and Lord, and who most earnestly and constantly aim to fashion their own lives on the model of his—that there is the greatest readiness to admit that the records of that life are tinged by the prepossessions, and subject to the inaccuracies, to which all human testimony is liable.

It was nobly said thirty years ago[2] (I believe by Francis Newman) that "every fresh advance of certain knowledge apparently sweeps off a portion of (so-called) religious belief, *but only to leave the true religious element more and more pure; and in proportion to its purity will be its influence for good, and for good only;*" and that, "little as many are aware of it, faithlessness is often betrayed in the struggle to retain in the region of faith that which is already passing into the region of science, for it implies doubt of the value of truth." Thoroughly sympathizing with this view—in no spirit of hostility to what is commonly regarded as revealed truth—but with a desire to promote the discriminating search for what really constitutes revealed truth, I offer the following suggestions, arising out of the special studies which have occupied a large part of my life, to the consideration of such as may deem them worthy of attention.

That the whole tendency of recent scientific inquiry has been to strengthen the notion of "continuity" as opposed to "cataclysms" and "interruptions," and to substitute the idea of progressive "evolution" for that of "special creations," cannot but be obvious to every one who is familiar with the progress of inquiry in astronomy, physical geology, paleontology, and biology. But the scientific theist who regards the so-called "laws of Nature" as nothing else than man's expressions of so much of the divine order as it lies within his power to discern, and who looks at the uninterruptedness of this

in the divine mind—as typified by the well-known illustration supplied by Mr. Babbage from his calculating-machine. But this obviously puts altogether on one side the notion of miracles as extraordinary interpositions, involving a more direct personal agency than the ordinary uniformity.

[1] "The brightness of his glory, and the express image of his person."

[2] *Prospective Review*, vol. i., p. 53.

order as the highest evidence of its original perfection, need find (as it seems to me) no abstract difficulty in the conception that the author of Nature can, if he will, occasionally depart from it. And hence, as I deem it presumptuous to deny that there might be occasions which in his wisdom may require such departure, I am not conscious of any such scientific "prepossessions" against miracles as would prevent me from accepting them as facts, if trustworthy evidence of their reality could be adduced. The question with me, therefore, is simply, "Have we any adequate historical ground for the belief that such departure has ever taken place?"

Now, it can scarcely be questioned that, while the scientific probability of uniform sequence has become stronger, the value of testimony in regard to departures from it has been in various ways discredited by modern criticism. It is clear that the old arguments of Lardner, and the modern reproduction of them by Prof. Andrews Norton (Boston, New England), which in my early days were held as demonstrating the "genuineness of the Gospels," no longer possess their former cogency. For the question has now passed into a phase altogether different from that which it presented a century or two ago. It was then, "Are the narratives genuine or fictitious? Did the narrators intend to speak the truth, or were they constructing a tissue of falsehoods? Did they really witness what they narrate, or were they the dupes of ingenious story-tellers?" It is now, "Granting that the narrators wrote what they firmly believed to be true, as having themselves seen (or thought they had seen) the events they recorded, or as having heard of them from witnesses whom they had a right to regard as equally trustworthy with themselves, is *their* belief a sufficient justification for *ours?* What is the extent of allowance which we are to make for 'prepossession'—1. As modifying their conception of each occurrence at the time; and 2. As modifying their subsequent remembrance of it? And 3. In cases in which we have not access to the original records, what is the amount of allowance which we ought to make for the accretion of other still less trustworthy narratives around the original nucleus?"

Circumstances have led me from a very early period to take a great interest in the question of the value of testimony, and to occupy myself a good deal in the inquiry as to what is scientifically termed its "subjective" element. It was my duty for many years to study and to expound systematically to medical students the probative value of different kinds of evidence; and my psychological interest in the curious phenomena which, under the names of mesmerism, odylism, electro-biology, psychic force, and spiritual agency, have been supposed to indicate the existence of some new and mysterious force in Nature, led me, through a long series of years, to avail myself of every opportunity of studying them that fell within my reach. The general result of these inquiries has been to force upon me the conviction that, as

to all which concerns the "supernatural" (using that term in its generally understood sense, without attempting a logical definition of it), the allowance that has to be made for "prepossession" is so large as practically to destroy the validity of any testimony which is not submitted to the severest scrutiny according to the strictest scientific methods. Of the manner in which, within my own experience, what seemed the most trustworthy testimony has been completely discredited by the application of such methods, I shall give some examples hereafter.

I would by no means claim for myself or any other scientific man an immunity from idolatrous prepossessions; for we must all be guided in our researches by *some* notion of what we expect to find; and this notion may be very misleading. Thus, when no metal was known that is not several times heavier than water, it was not surprising that Dr. Pearson, as he poised upon his finger the first globule of potassium produced by the battery of Davy, should have exclaimed, "Bless me, how heavy it is!" though, when thrown into water, the metal floated upon it. But while the true disciple of Bacon is on his guard against "idolatry," and is constantly finding himself rudely handled (as Dr. Pearson was) by "the irresistible logic of facts" if he falls into it, the pledged upholder of any religious system can be scarcely other than, in some degree, an "idolater." The real philosopher, says Schiller, is distinguished from the "trader in knowledge" by his "always loving truth better than his system."

Bacon's classification of "idols" is based on the *sources* of our prepossessions; and, although his four types graduate insensibly into each other, yet the study of them is very profitable. Sir John Herschel is, I think, less successful when he classifies them as—1. Prejudices of opinion, and 2. Prejudices of sense; because an analysis of any of his "prejudices of sense" shows that it is really a "prejudice of opinion." My first object is to show that we are liable to be affected by our prepossessions at every stage of our mental activity, from our primary reception of impressions from without, to the highest exercise of our reasoning powers; and that the value of the testimony of any individual, therefore, as to any fact whatever, essentially depends upon his freedom from any prepossessions that can affect it.

That our own states of consciousness constitute what are, to each individual, the most certain of all truths—in a philosophical sense (as J. S. Mill says) the only certain truths—will, I suppose, be generally admitted; but there is a wide *hiatus* between this and the position that every state of consciousness which represents an external object has a real object answering to it. In fact, although we are accustomed to speak of "the evidence of our senses" as worthy of the highest credit, nothing is easier than to show that the evidence of any one sense, without the check afforded by comparison with that of another, is utterly untrustworthy.

I might pile up instances of visual illusion, for example, in which the subject would be ready to affirm without the slightest hesitation that he sees something which greatly differs from the object that actually forms the picture on his retina; his erroneous interpretation of that picture being the result of a prepossession derived from antecedent experience. I could show, too, that the same picture may be interpreted in two different modes: a skeleton-diagram, for example, suggesting two dissimilar solid forms, according as the eyes are fixed on one or another of its angles; and a photograph of a coin or fossil being seen as a cameo or as an intaglio, according as the position of the light affects the interpretation of its lights and shadows. Again, I have before me two pieces of card, A and B, of similar form: when A is placed *above* B, the latter is unhesitatingly pronounced the larger; if their relative positions be reversed, A is pronounced, with equal conviction, to be the larger; yet, when one is laid *upon* the other, they are found to be precisely equal in size.

So, again, in those more complex combinations of natural objects which the pictorial artist aims to represent, the different modes in which the very same scene shall be treated, by two individuals working at the same time and from the same point of view, show how differently they interpret the same visual picture, according to their original constitution and subsequent training. As Carlyle says, "The eye sees what it brings the power to see."

But mental prepossessions do much more than this; they *produce* sensations having no objective reality. I do not here allude to those "subjective sensations" of physiologists which depend upon physical affections of nerves in their course, the circulation of poisoned blood in the brain (as in the delirium of fever), and the like; but I refer to the sensations produced by *mental expectancy*, a most fertile source of self-deception. The medical practitioner is familiar with these in the case of "hysterical" subjects; whose pains are as real experiences to them as if they originated in the parts to which they are referred. And I have no reason to doubt that the "sensitives" of Reichenbach really saw the flames they described as issuing from magnets in the dark—as a very honest and highly-educated gentleman assured me that he did, not only when the magnet was there, but when he believed it to be still there (in the dark), after it had been actually withdrawn. So there are "sensitives" in whom the drawing of a magnet along the arm will produce a sensible *aura* or a pricking pain; and this will be equally excited by the belief that the magnet is being so used, when nothing whatever is done.

Now, the phenomena of which these are simple examples appear to me to have this physiological signification—that changes in the cerebrum which answer to the higher mental states act *downward* upon the sensorium at its base, in the same manner as changes in the organs of sense act *upward* upon it; the very same state of the sen-

sorium being producible through the nerves of the *internal* and of the *external* senses, and the very same affection of the sensational consciousness being thus called forth by impressions *ab extra* and *ab intra*. Thus, individuals having a strong pictorial memory can reproduce scenes from Nature, faces, or pictures, with such vividness that they may be said to see with their "mind's eye" just as distinctly as with their bodily eye; and there is an instance on record (which Mr. Ruskin fully accredits, as well from having seen the two pictures as from his own similar experiences) in which a painter at Cologne accurately reproduced from memory a large altar-piece by Rubens, which had been carried away by the French. Those, again, who possess a strong pictorial imagination, can thus *create* distinct visual images of what they have never seen through their bodily eyes. And, although this power of voluntary representation is comparatively rare, yet we are all conscious of the phenomenon as occurring involuntarily in our dreams.

Now, there is a very numerous class of persons who are subject to what may be termed "waking dreams," which they can induce by placing themselves in conditions favorable to reverie; and the course of these dreams is essentially determined by the individual's prepossessions, brought into play by suggestions conveyed from without. In many who do not spontaneously fall into this state, fixity of the gaze for some minutes is quite sufficient to induce it; and the "mesmeric mania" of Edinburgh in 1851 showed the proportion of such susceptible individuals to be much larger than was previously supposed. Those who have had adequate opportunities of studying these phenomena find no difficulty in referring to the same category many of the "spiritualistic" performances of the present time, in which we seem to have reproductions of states that were regarded in ancient times, under the influence of religious prepossession, as results of divine inspiration. I have strong reason to believe (from my conviction of the honesty of the individuals who have themselves narrated to me their experiences) that they have really seen, heard, and felt what they describe, where intentional deception was out of the question; that is, that they had the same distinct consciousness, in states of expectant reverie, of seeing, touching, and conversing with the spirits of departed friends, that most of us occasionally have in our dreams. And the difference consists in this—that while one, in the exercise of his common-sense, dismisses these experiences as the creation of his own brain, having no objective reality, the other, under the influence of his prepossession, accepts them as the results of impressions *ab extra* made upon him by "spiritual" agencies.

The faith anciently placed, by the heathen as well as the Jewish world, in dreams, visions, trances, etc., has thus its precise parallel in the present day; and it is not a little instructive to find a very intelligent religious body, the Swedenborgians, implicitly accepting as au-

thoritative revelation the visions of a man of great intellectual ability and strong religious spirit, but highly imaginative disposition, the peculiar feature of whose mind it was to dwell upon his own imaginings. These he seems to have so completely separated from his worldly life, that the Swedenborg who believed himself to hold intercourse with the spiritual world and Swedenborg the mechanician and metallurgist may almost be regarded as two distinct personalities.

If, then, the high scientific attainments of some of the prominent advocates of "spiritualism," and our confidence in their honesty, be held to require our assent to what they narrate as their experiences, in regard to a class of phenomena which they declare that they have witnessed, but which they cannot reproduce for the satisfaction of other men of science who desire to submit them to the rigorous tests which they regard as necessary to substantiate their validity, then we must, in like manner, accept the records of Swedenborg's revelations as binding on our belief. That they were *true to him* I cannot doubt; and, in the same manner, I do not question that Mr. Crookes is thoroughly honest when he says that he has repeatedly witnessed the "levitation of the human body." But I can regard his statements in no other light than as evidence of the degree in which certain minds are led, by the influence of strong "prepossession," to believe in the creations of their own visual imagination.

All history shows that nothing is so potent as religious enthusiasm, in fostering this tendency; the very state of enthusiasm, in fact, being the "possession" of the mind by fixed ideas, which overbear the teachings of objective experience. These, when directed to great and noble ends, may overcome the obstacles which deter cooler judgments from attempting them; but, on the other hand, may also move not only individuals but great masses of people to extravagances at which sober common-sense revolts; as the history of the Flagellants, the Dancing Mania, and other religious epidemics of the middle ages, forcibly illustrates. And nothing is more remarkable, in the history of these epidemics, than the vividness with which people who were not asleep saw visions that were obviously inspired by the prevalent religious notions of their times. Thus, some of the dancers saw heaven opened, and the Saviour enthroned with the Virgin Mary; while others saw hell yawning before their feet, or felt as if bathed in blood; their frantic leaps being prompted by their eagerness to reach toward the one or to escape from the other.

In the next place, I would briefly direct attention to the influence of prepossessions on those *interpretations* of our sensational experiences which we are prone to substitute for the statement of the experiences themselves. Of such misinterpretations, the records of science are full; the tendency is one which besets every observer, and to which the most conscientious have frequently yielded; but I do not know any more striking illustrations of it than I could narrate from

my own inquiries into mesmerism, spiritualism, etc. The most diverse accounts of the *facts* of a *séance* will be given by a believer and a skeptic. One will declare that a table rose in the air, while another (who had been watching its feet) is confident that it never left the ground; a whole party of believers will affirm that they saw Mr. Home float out of one window and in at another, while a single honest skeptic declares that Mr. Home was sitting in his chair all the time. And in this last case we have an example of a fact, of which there is ample illustration, that during the prevalence of an epidemic delusion the honest testimony of any number of individuals on one side, if given under a "prepossession," is of no more weight than that of a single adverse witness—if so much. Thus I think it cannot be doubted by any one who candidly studies the witchcraft trials of two centuries back, that, as a rule, the witnesses really believed what they deposed to as facts; and it further seems pretty clear that in many instances the persons incriminated were themselves "possessed" with the notion of the reality of the occult powers attributed to them. No more instructive lesson can be found, as to the importance of the "subjective" element in human testimony, than is presented in the records of these trials. Thus, Jane Brooks was hung at Chard assizes in 1658, for having bewitched Richard Jones, a sprightly lad of twelve years old; he was seen to rise in the air and pass over a garden-wall some thirty yards; and nine people deposed to finding him, in open daylight, with his hands flat against a beam at the top of the room, and his body two or three feet from the ground! If this "levitation of the human body," confirmed as it is in modern times by the testimony of Mr. Crookes, Lord Lindsay, and Lord Adair, to say nothing of the dozen witnesses to Mrs. Guppy's descent through the ceiling of a closed and darkened room, has a valid claim on our belief, how are we to stop short of accepting, on the like testimony, *all* the marvels and extravagances of witchcraft? If, on the other hand, we put these witnesses out of court, as rendered untrustworthy by their "prepossession," what credit can we attach to the testimony of any individuals or bodies dominated by a strong religious "prepossession;" that testimony having neither been recorded at the time, nor subjected to the test of judicial examination?

Though I have hitherto spoken of "prepossessions" as ideational states, there are very few in which the emotions do not take a share; and how strongly the influence of these may pervert the representations of actual facts, we best see in that early stage of many forms of monomania, in which there are as yet no fixed delusions, but the occurrences of daily life are wrongly interpreted by the emotional coloring they receive. But we may recognize the same influence in matters which are constantly passing under our observation; and a better illustration of it could scarcely be found than in the following circumstance, mentioned to me as having recently occurred in the practice

of a distinguished physician: The head of a family having been struck down by serious illness, this physician was called in to consult with the ordinary medical attendant; and, after examining the patient and conferring with his colleague, he went into the sitting-room where the family were waiting in anxious expectation for his judgment on the case. This he delivered in the cautious form which wise experience dictated: "The patient's condition is very critical, but I see no reason why he should not recover." One of the daughters screamed, "Dr. —— says papa will die!" another cried out, in a jubilant tone, "Dr. —— says papa will get well." If no explanation had been given, the two ladies would have reported the physician's verdict in *precisely opposite terms*, one being under the influence of *fear*, the other of *hope*.

I shall now give a few illustrative examples, from recent experiences, of the contrast between the two views taken of the same phenomena (1) by such as are led by their "prepossessions" at once to attribute to "occult" influences what they cannot otherwise explain, and (2) by those who, under the guidance of trained and organized common-sense, apply themselves, in the first instance, to determine whether there be any thing in these phenomena which "natural" agencies are *not* competent to account for:

1. When, in 1853, the "table-turning" epidemic had taken so strong a hold of the public mind that Prof. Faraday found himself called upon to explain its supposed mystery, he devised a very simple piece of apparatus for testing the fundamental question, whether there is any evidence that the movements of the table are due to *any thing else* than the muscular action of the performers who place their hands upon it. And having demonstrated by its means (1) that the table never went round unless the "indicator" showed that lateral pressure had been exerted in the direction of the movement, while (2) it always did go round when the "indicator" showed that such lateral pressure was adequately exerted, he at once saw that the phenomenon was only another manifestation of the involuntary "ideo-motor" action which had been previously formulated, on other grounds, as a definite physiological principle; and that there was, therefore, not the least evidence of any other agency. Yet it is still asserted that the validity of Faraday's test is completely disproved by the conviction of the performers that they do not exert any such agency; all that this proves being that they are *not conscious* of such exertion—which, to the physiologist, affords no proof whatever that they are not making it.

2. So, again, Profs. Chevreul and Biot, masters of experimental science worthy to be placed in the same rank with Faraday, had been previously applying the same principles and methods to the systematic investigation of the phenomena of the divining-rod and the oscillations of suspended buttons; the former of which were supposed to depend upon some "occult" power on the part of the performer, while the latter were attributed to an hypothetical "odylic" force. And they conclusively proved that in both cases the results are brought about (as in table-turning) by the involuntary action of mental expectancy on the muscles of the performer; the phenomena either not occurring at all, or having no constancy whatever, when he neither knows nor guesses *what to expect*.—The following

instance of the application, to the phenomena of the divining-rod, of the very simple test of *closing the eyes*, has lately been sent me by an American friend, who was apparently unaware of its former application by Chevreul and Biot: "An aged clergyman, of thorough integrity, has for many years enjoyed the reputation of being specially skilled in the finding of places to dig wells by means of the 'divining-rod.' His fame has spread far; and the accounts that are given by him, and of him, must be, to those who place an implicit reliance on human testimony, overwhelmingly convincing. He consented to allow me to experiment with him, and I found that only a few moments were required to prove that his fancied gift was a delusion. In his own yard there was known to be a stream of water running a few feet below the surface, through a small pipe. As he marched over and near this, the rod continually pointed strongly downward, and several times turned clear over. These places I marked, and then blindfolded him, and marched him about until he knew not where he was, taking him over the same ground over and over again; and although the rod went down a number of times, *it did not once point to or near the places indicated.*"

3. About twenty-five years ago, when the old phenomena of the oscillations of suspended buttons, developed by Dr. H. Mayo into a pseudo-scientific theory of od-force, were strongly exciting public attention, a medical friend of great intelligence, then residing in the south of France, wrote me long letters giving the results of his surprising experiences, and asking what I regarded as their *rationale*. My reply was simply, "Shut your eyes, and let some one else observe the oscillations." In a short time I heard from him again, to the effect that his reinvestigation of the matter under this condition had satisfied him that there was no other agency concerned than his own involuntary muscular movement, directed by his *mental expectancy* of the results which would ensue.

In the foregoing cases, the honest beliefs of the agents themselves brought about the results; in the following these beliefs were taken up by the witnesses to the performances of others, in spite of all common-sense probability to the contrary, under the influence of their own strong "prepossessions."

4. At a spiritualistic *séance* at which I was present, at an early stage of the present epidemic, the "medium" pressed down one side of a large loo table supported on a pedestal springing from three spreading feet, and left it resting on only two of its feet, with its surface at an angle of about 45°. Having been admitted to this *séance* under a promise of non-interference, I waited until its conclusion; and then, going over to the table, *set it up and left it in the same position*. For I had observed, when this was done by the "medium," that the edge of the broad claw of each foot, and the edge of its castor, bore on the ground together, so as to afford a base which, though narrow, was sufficient for the table to rest on, its weight happening to be balanced when thus tilted half over. Several persons of great intelligence who were present at this *séance* (Mr. Robert Chambers among the rest) assured me that, if it had not been for my exposure of this trick, they should have gone away in the belief that the table was sustained by "spiritual" influence, as in no other way could they suppose it to have kept its position against the force of gravity.

5. So strong was the impression made by the rope-tying and other performances of the Davenport brothers, about twenty years ago, upon those who were already prepossessed in favor of their "spiritualistic" claims, that I was pressed by men of distinguished position to become a member of a committee

for their "scientific" investigation. Having a strong prepossession, however, in favor of the common-sense view that these performances were but the tricks of not very clever jugglers, and learning that this inquiry was to take place in a darkened room, and that the members of the committee must form a circle with joined hands, I at once declined to have any thing to do with it; on the ground that, to exclude the use of the eyes and hands, which the scientific investigator uses as his chief instruments of research, was to render the inquiry utterly nugatory. Now that the tricks of the Davenport brothers have been not merely imitated but surpassed by Messrs. Cooke and Maskelyne, I suppose that no truly "rational" person would appeal to them as evidence of "spiritual" agency.

6. During the meeting of the British Association at Belfast in 1874, a lady-medium of great repute held spiritualistic *séances*, at which she distributed flowers, affirmed to have been brought to her then and there by the spirits, fresh from the garden, with the dew of heaven upon them. As there was nothing more in this performance than is done every day by an ordinary conjurer, only the confidence entertained in the good faith of the medium could justify a belief in the "spiritual" transport of the flowers; but this belief, aided by the general "prepossession," had been implicitly accepted by many of the witnesses on such occasions. An inquisitive young gentleman, however, who was staying in the same house, and did not share in this confidence, found a basin-full of these flowers (hollyhocks) in a garret, with a decanter of water beside it; and strongly suspecting that they had been stored there with a view to distribution at the *séance*, and that the dew would be supplied, when wanted, from the decanter, he conveyed into the water a chemical substance (ferrocyanide of potassium), in quantity so small as not to tinge it, and yet to be distinctly recognizable by the proper test. On the subsequent application of this test (a per-salt of iron) to the flowers distributed by the "medium," they were found to give *Prussian blue*.—This is no piece of hearsay, but a statement which I have in the hand of the gentleman himself, with permission to make it public.

But every form of "prepossession" has an involuntary and unsuspected action in modifying the memorial traces of past events, even when they were originally rightly apprehended. A gradual change in our own mode of viewing them will bring us to the conviction that we always so viewed them; as we recently saw in the erroneous account which Earl Russell gave of his action as Foreign Secretary in the negotiations which preceded the Crimean War. His subsequently-acquired perception of what he should have done at a particular juncture wrought him up to the honest belief that he really did it. To few persons of experience in life has it not happened to find their distinct impressions of past events in striking discordance with some contemporary narrative, as perhaps given in a letter of their own. An able lawyer told me not long since that he had had occasion to look into a deed which he had not opened for twenty years, but which he could have sworn to contain certain clauses; and, to his utter astonishment, the clauses were not to be found in it. His habitual conception of the purpose of the deed had constructed what answered to the actual memorial trace.

Now, this constructive process becomes peculiarly obvious, in a comparison of narratives given by the believers in mesmerism, spiritualism, and similar "occult" agencies, when there has been time for the building-up of the edifice, with contemporary records of the events, made perhaps by the very narrators themselves. Every thing which tends to prove the reality of the occult influence is exaggerated or distorted; every thing which would help to explain it away is quietly (no doubt quite unintentionally) dropped out. And convictions thus come to be honestly entertained which are in complete disaccordance with the original facts. This source of fallacy was specially noticed by Bacon:

"When the mind is once pleased with certain things, it draws all others to consent, and go along with them; and though the power and number of instances that make for the contrary are greater, yet it either attends not to them, or despises them, or else removes them by a distinction, with a strong and pernicious prejudice to maintain the authority of the first choice unviolated. And hence in most cases of superstition, as of astrology, dreams, omens, judgments, etc., those who find pleasure in such kind of vanities *always observe where the event answers, but slight and pass by the instances where it fails, which are much the more numerous.*"—NOVUM ORGANON.

Of the manner in which this constructive process will build up a completely ideal representation of a personality (with or without a nucleus of reality), which shall gain implicit acceptance among a whole people, and be currently accepted by the world at large, we have a "pregnant instance" in the William Tell tradition. For the progressive narrowing-down of his claims, which has resulted from the complete discordance between the actions traditionally attributed to him and trustworthy contemporary history, leaves even his personality questionable; while the turning-up of the apple-story in Icelandic sagas and Hindoo myths seems to put it beyond doubt that this, at any rate, is drawn from far older sources. The reality of this process of gradual accretion and modification, in accordance with current ideas in regard to the character of an individual or the bearing of an event, cannot now be doubted by any philosophic student of history. And the degree in which such constructions involve ascriptions of supernatural power can be shown in many instances to depend upon the prevalent notions entertained as to what the individual might be expected to do.

No figure is more prominent in the early ecclesiastical history of Scotland than that of St. Columba, "the Apostle of the Scoto-Irish," in the sixth century. Having left Ireland, his native country, through having, by his fearless independence, been brought into collision with its civil powers, and been excommunicated by its Church-synods, he migrated to Scotland in the year 563, and acquired by royal donation the island of Iona, which was a peculiarly favorable centre for his evangelizing labors, carried on for more than thirty years among the

Picts and Scots, and also among the northern Irish. No fewer than thirty-two separate religious foundations among the Scots, twenty-one among the Picts, and thirty-seven among the Irish, many of which occupied conspicuous places in the monastic history of the earlier middle ages, seem to have been planted by himself or his immediate disciples; the most celebrated of all these being the college of the Culdees, at Iona, which kept alive the flame of learning during a prolonged period of general ignorance and superstition, and became a centre of religious influence, which extended far beyond the range of its founder's personal labors, and caused his memory to be held in the deepest veneration for centuries afterward. The point on which I here desire to lay stress is *the continuity of history*, as trustworthy as any such history can be; the incidents of St. Columba's life having been originally recorded in the contemporary *fasti* of his religious foundation, and transmitted in unbroken succession to Abbot Adamnan, who first compiled a complete "Vita" of his great predecessor, of which there still exists a manuscript copy, whose authenticity there is no reason to doubt, which dates back to the early part of the eighth century, not much more than one hundred years after St. Columba's death. Now, Adamnan's "Vita" credits its subject with the possession of every kind of miraculous power. The saint prophesied events of all kinds, trivial as well as grave, from battles and violent deaths down to the spilling of an ink-horn, the falling of a book, the omission of a single letter from a writing, and the arrival of guests at the monastery. He cured numbers of people afflicted with inveterate diseases, accorded safety to storm-tossed vessels, himself walked across the sea to his island-home, drove demons out of milk-pails, outwitted sorcerers, and gave supernatural powers to domestic implements. Like other saints, he had his visions of angels and apparitions of heavenly light, which comforted and encouraged him at many a trying juncture, lasting, on one occasion, for three days and nights.

Now, it seems to me beyond all reasonable doubt that St. Columba was one of those men of extraordinary energy of character and earnest religious nature who have the power of strongly impressing most of those with whom they come into contact, moulding their wills and awakening their religious sympathies, so as to acquire a wonderful influence over them; this being aided by the commanding personal "presence" he is recorded to have possessed. And it is not surprising that, when themselves the subjects of what they regarded as "supernatural" power, they should attribute to him the exercise of the same power in other ways. In fact, to their unscientific minds it seemed quite "natural" that he should so exert it; its possession being, in their belief, a normal attribute of his saintship. That he himself believed in his gifts, and that many wonders were actually worked by the concurrent action of his own faith in himself and his followers' faith in him, will not seem unlikely to any one who has carefully

studied the action of mental states upon the bodily organism. And that round a nucleus of truth there should have gathered a large accretion of error, under the influence of the mental preconception whose *modus operandi* I have endeavored to elucidate, is accordant with the teachings of our own recent experience, in such cases as that of Dr. Newton and the Zouave Jacob. In these and similar phenomena, a strong conviction of the possession of the power on the part of the healer seems to be necessary for the excitement of the faith of those operated on; and the healer recognizes, by a kind of intuition, the existence of that faith on the part of the patient. Do not several phrases in the gospel narratives point to the same relations as existing between Jesus and the sufferers who sought his aid? The cure is constantly attributed to the "faith" of the patient; while, on the other hand, we are told that Jesus did not do many mighty works in his own country "because of their unbelief"—the very condition which, if these mighty works had been performed by his own will alone, would have been supposed to call forth its exertion, but which is perfectly conformable to our own experience of the wonders of mesmerism, spiritualism, etc. So Paul is spoken of as "steadfastly beholding" the cripple at Lystra, "and seeing that he had faith to be healed."

The potency of influences of the opposite kind upon minds predisposed to them, and through their minds upon their bodies, is shown in the "Obeah practices" still lingering among the negroes of the West India colonies, in spite of most stringent legislation. A slow pining away, ending in death, has been the not unfrequent result of the fixed belief on the part of the victim that "Obi" has been put upon him by some old man or old woman reputed to possess the injurious power; and I see no reason to doubt that the Obi men or women were firm believers in the occult power attributed to them.

Every medical man of large experience is well aware how strongly the patient's undoubting faith in the efficacy of a particular remedy or mode of treatment assists its action; and, where the doctor is himself animated by such a faith, he has the more power of exciting it in others. A simple prediction, without any remedial measure, will sometimes work its own fulfillment. Thus, Sir James Paget tells of a case in which he strongly impressed a woman, having a sluggish, non-malignant tumor in the breast, that this tumor would disperse within a month or six weeks; and so it did. He perceived the patient's nature to be one on which the assurance would act favorably, and no one could more earnestly and effectually enforce it. On the other hand, a fixed belief on the part of the patient that a mortal disease has seized upon the frame, or that a particular operation or system of treatment will prove unsuccessful, seems in numerous instances to have been the real occasion of the fatal result.

Many of the so-called "miracles" of the Romish Church, such as

that of the "holy thorn" (narrated in the "History of the Port-Royalists"), which stood the test of the most rigid contemporary inquiry, carried on at the prompting of a hostile ecclesiastical party, seem to me fully explicable on the like principle of the action of strongly-excited "faith" in producing bodily change, whether beneficial or injurious; and nothing but the fact that this strong excitement was called forth by religious influences, which in all ages have been more potent in arousing it than influences of any other kind, gives the least color to the assumption of their supernatural character.

I might draw many other illustrations from the lives of the saints of various periods of the Roman Catholic Church, as chronicled by their contemporaries, many of whom speak of themselves as eye-witnesses of the marvels they relate; thus, the "levitation of the human body"—i. e., the rising from the ground, and the remaining unsupported in the air for a considerable length of time—is one of the miracles attributed to St. Francis d'Assisi. But it will be enough for me to refer to the fact that some of the ablest ecclesiastical historians in the English Church have confessed their inability to see on what grounds—so far as *externæl evidence* is concerned—we are to reject these, if the testimony of the Biblical narratives is to be accepted as valid evidence of the supernatural occurrences they relate.

But the most remarkable example I have met with in recent times of the "survival" in a whole community of ancient modes of thought on these subjects (the etymological meaning of the term "superstition") has been very recently made public by a German writer, who has given an account of the population of a corner of Eastern Austria, termed the Bukowina, a large proportion of which are Jews, mostly belonging to the sect of the Chassidim, who are ruled by "Saints" or "Just Ones." "These saints," says their delineator, "are sly impostors, who take advantage of the fanaticism, superstition, and blind ignorance of the Chassidim in the most barefaced manner. They heal the sick by pronouncing magic words, drive out devils, gain lawsuits, and their curse is supposed to kill whole families, or at least to reduce them to beggary. Between the 'saint' and 'God' there is no mediator, for he holds personal intercourse with the Father of all, and his words are oracles. Woe to those who should venture to dispute these miracles in the presence of these unreasonable fanatics! They are ready to die for their superstitions, and to kill those who dispute them."[1]

Now, I fail to see what stronger external evidence there is of any of the supernatural occurrences chronicled in the Old Testament than that which is afforded by the assured conviction of this Jewish community as to what is taking place at the present time under their own eyes. And, assuming, as I suppose most of us should be ready to do, that the testimony of these contemporary wonders would break down

[1] E. Kilian, in *Fraser's Magazine* for December, 1875.

under the rigorous test of a searching examination, I ask whether we are not equally justified in the assumption that a similar scrutiny, if we had the power to apply it, would in like manner dispose of many of the narratives of old time, either as distortions of real occurrences or as altogether legendary.

In regard to the New Testament miracles generally, while failing to see in what respect the external testimony in their behalf is stronger than it is for the reality of the miracles attributed to St. Columba, I limit myself for the present to the following questions:

1. Whether the "miracles of healing" may not have had a foundation of reality in "natural" agencies perfectly well known to such as have scientifically studied the action of the mind upon the body. In regard to one form of these supposed miracles—the casting out of devils—I suppose that I need not in these days adduce any argument to disprove the old notion of "demoniacal possession," in the face of the fact that the belief in such "possession" in the case of lunatics, epileptics, etc., and the belief in the powers of "exorcists" to get rid of it, are still as prevalent among Eastern nations as they were in the time of Christ. And I suppose, too, that, since travelers have found that the pool of Bethesda is fed by an intermittent spring, few now seriously believe in the occasional appearance of an "angel" who moved its water; or in the cure of the first among the expectant sick who got himself placed in it, by any other agency than his "faith" in the efficacy of the means. I simply claim the right to a more extended application of the same critical method.

2. Whether we have not a similar right to bring to bear on the study of the Gospel narratives the same *principles* of criticism as guided the early fathers in their construction of the canon, with all the enlightenment which we derive from the subsequent history of Christianity, aided by that of other forms of religious belief. The early Christian fathers were troubled with no doubts as to the reality of miracles in themselves; and they testified to the healing of the sick, the casting out of devils, and even the raising of the dead, as well-known facts of their own time. But they rejected some current narratives of the miraculous which they did not regard as adequately authenticated, and others as considering them puerile. Looking at it not only as our right, but as our duty, to bring the higher critical enlightenment of the present day to bear upon the study of the Gospel records, I ask whether both past and contemporary history do not afford such a body of evidence of a prevalent tendency to exaggeration and distortion, in the representation of actual occurrences in which "supernatural" agencies are supposed to have been concerned, as entitles us, without attempting any detailed analysis, to believe that, if we could know *what really did happen*, it would often prove to be something very different from what is narrated.

By such a general admission, we may remove the serious difficul-

ties to which I alluded at the outset, difficulties which must, I think, have been present to the mind of Locke, when he recorded, in the commonplace-book published by Lord King, the remarkable aphorism that "the doctrine proves the miracles, rather than the miracles the doctrine."—*Contemporary Review.*

THE FUNCTIONS OF ASSOCIATION IN ITS RELATION TO LABOR.

By WILLIAM B. WEEDEN.

THE writer is a member of a copartnership chiefly devoted to the business of manufacturing textile fabrics. Within twenty years this firm has divided interests in different mills with eight persons, who acted as superintendents or assistant superintendents of the mills in which they were engaged. These combinations were of the nature of industrial partnerships, and proved uniformly successful. Of these eight persons, two were originally factory accountants, two were finishing overseers, and four were weaving overseers; all were men who had served long in the factories, and were outgrowths from factory-life. If it be true that in the armies of Napoleon every private carried a marshal's *bâton* in his knapsack, or, as Sydney Smith puts it, if every English curate is a possible bishop, then these industrial combinations must have produced better cloth for the people and a better life in the makers of the cloth, or the laborers who were confined in the factories. The firm owned or controlled ample capital for their enterprises, and employed the laborers. It needs no argument to show that the business was more thoroughly done because these industrial partners were taken from among the laborers; and it is likewise evident that each rank of laborers was elevated and stimulated by these promotions.

Under that modern system of organization which unites the laborers into one mass, striving to obtain the highest price for their services, and combines employers in another assembly seeking to obtain labor at the lowest price, our industrial partnerships would have been impossible. If close combinations resulting in certain antagonism, such as has prevailed in England for a generation, had existed here, then no links could have reached across from the chain of laborers on the one side to the chain of employers and capitalists on the other. These combinations are growing in America; the life they foreshadow must differ from the industrial life described above. It was this thought which led me to consider the matter, and to try to ascertain the true functions of association. The topic is broader than my theme, and enters into all phases of civilized society, but I would con-

sider it in the relations of organized labor, which include the so-called labor and capital (or capital and labor) disputes. The same principles of association prevail here which dominate all social action. What are the powers, the rights, and the limits of association, whether it be of the employers or the employed? I shall resolve the question of rights into that of powers. If there be a legitimate power inherent in these associations, I will not maintain any vested right against it. This is not strictly accurate, but sufficiently so for this discussion.

In treating of association we must first consider the materials which make it; the characteristics of the individuals who associate themselves together. And here we must remember that the individual is a social entity of quite recent growth. The Roman, German, Anglo-Saxon societies knew nothing of individual men and women. The Roman family, *gens*, or house and tribe, the German benefice, commendation, and guild, the Anglo-Saxon *ceorl* and *eorl* castes, with their tithings and hundreds—all these institutions, mingling in the stream of history, made each individual into a part of something other than himself. Society as well as government was classified into groups, which were further classified and subdivided. The single individual had no place; under the Saxon laws he was outlawed, and might be killed. These groups gradually broke up, under the friction of modern life. America, as we have been frequently told in the centennial reminiscences of this period, for two hundred years received the germinal ideas of Europe. We received, through immigration, the most characteristic and modern ideas, and incorporated them into a new political and social life, freed from many restraints still prevailing in the old countries. Politically, the individual was fully recognized for the first time; socially, he was raised into freer activity than any society had ever developed; yet, socially, the individual was more limited by the influence of the old grouping than he was in his political relations. These distinctions are important, because they modify all the subsequent relations of employers and employed, and control the character of associations in this country.

The associations of employers in America thus far have been loosely formed, and their action on the labor question has been indirect. The associations of laborers have been modeled after those prevailing in England, and known as trades-unions. If we would comprehend the principles of any association of laborers in America, we must first study the history of these English unions, for the results achieved by these powerful organizations govern the movements of all labor agitators, whether they are conscious of it or not. The whole principle of trades-unionism has been set forth carefully and candidly by Mr. Thornton in his work "On Labor." Mr. Thornton is neither a communist nor a socialist, but an acute and thoughtful Englishman, with large sympathies, who, whenever his sense of justice will allow, leans to the side of labor in its struggles with capital. He sees in

labor, as capital, not theories, but immense and awful facts which must bruise and grind each other until they are worn into some finer social relations. The idea that some wrong principles in the first constitution of the facts might be changed, and the whole result might be ameliorated, never occurs to him. The whole affair must be fought out representatively and fairly; and, when the strongest force has manifested itself, right will prevail. He admits the many evils of trades-unionism, stating them with candor and force. But he believes the institution to be absolutely necessary. He says, on page 320:

"Laborers may, by combining, acquire an influence which, if exercised with moderation and discretion, employers will in general be willing rather to propitiate than to oppose. Among the concessions which may in consequence be obtained by unionists, the most material are those which affect the remuneration of labor, and these, it is commonly supposed, cannot, when due solely to unionist action, be of permanent operation. We have learned, however, in the course of the present chapter, that the fact of an increase in the rate of remuneration having been artificially caused, furnishes no reason why, in the great majority of cases, that increase should not be lasting. . . . Such being the efficacy of unionism, there is no difficulty in accounting for its popularity without resorting, in explanation of unionist loyalty, to any of those terrorist theories, the exaggerations of which have already been exposed, and on which no additional words need here be expended."

Mr. Thornton supports the extraordinary theory that an artificial rise of wages may be made into a permanent value by reconstructing the whole formula of supply and demand as it is enunciated by economists and men of affairs. He says, on page 108:

"The price of labor is determined, not by supply and demand, which never determined the price of any thing, nor yet by competition, which generally determines the price of everything else, but by combination among the masters. Competition in a small minority of cases, combination in a great majority, have appeared to be normally the determining causes of the rate of wages or price of labor."

It is not necessary to refute this theory in its relation to price and value—it refutes itself; common facts, occurring since he wrote, have nullified it. I am only stating the basis of trades-unionism in the words of its most intelligent advocate. It is interesting to compare these doctrines of Mr. Thornton with those of Josiah Warren, an American socialist, who approaches the question from the opposite direction. Mr. Warren works his theory of value, price, and supply and demand, out of the sovereignty of the individual, as he terms it; while Mr. Thornton's comes out of the historic organization of society, political and social, as well as economical. Mr. Warren was an earnest man, who has had and now has a great influence in forming the opinions of laborers and labor-agitators in this country. He says in his pamphlet on "True Civilization" (pages 41, 64, 100):

"It is now evident to all eyes that labor does not obtain its legitimate reward, but, on the contrary, that those who work the hardest fare the worst. . . . . At this point society must attend to the rights of labor, and settle once for all the great problem of its just reward. This appears to demand a discrimination, a disconnection, a disunion, between *cost* and *value*. . . . Making value, or 'what a thing will bring,' the limit of its price, stagnates exchange and prevents our wants from being supplied. Now, if it were not a part of our present system to get a price according to the degree of want or suffering of the community, there would long since have been some arrangement made to *adapt* the *supply* to the *demand*. . . . Cost being made the limit of price, would give to the washer-woman a greater income than the importer of foreign goods; that this would entirely upset the present system of national trade, stop all wars arising out of the scramble for the profits of trade, and demolish all tariffs, duties, and all systems of policy that give rise to them; would abolish all distinctions of rich and poor; would enable every one to consume as much as he produced, and, consequently, prevent any one from living at the cost of another without his or her consent."

The difficulty underlying these two economical theories is the same, as I understand it. Mr. Thornton, and in a certain degree the political economists also, convert supply and demand into two entities. Take his illustration (page 59):

"Suppose at each of two horse-fairs a horse to be sold valued by its owner at £50, and suppose there be in the one case two and in the other three persons, of whom each is ready to pay £50 for the horse, though no one of them can afford to pay more. In both cases supply is the same—viz., one horse at £50—but demand is different, being in the one case two and in the other three horses at £50. Yet the price at which the horse will be sold will be the same in both cases, viz., £50."

Here he assigns a metaphysical limit to supply, and yet admits only a portion of the mental process by which that limit is reached. The fact that the buyers can afford to pay only £50 has little to do with the price paid. The cause which influences their mental action is, that they know there are plenty of other horses they can buy at £50, though there is only one at hand. Economically, the absent horses enter into the supply nearly as effectively as the one present. This supply, present and absent, affects the minds of both buyer and seller, and limits the price; the limit is not a metaphysical one, imposed by the competition of sellers alone, as Mr. Thornton would have us believe, and as he directly says elsewhere. We must bear in mind that Mr. Thornton has been partially approved by Mill and Prof. Cairns, in considering the weight of his theories. In the relations of capital and labor, he assumes that capitalists have the same control of the market-price of labor which he conceives sellers to have in ordinary trade; hence the necessity of trades-unionism to resist this control, which could not be governed by the economical forces of the market; and hence the above formula of supply and demand. Mr. Warren's error is essentially the same. In his view, the price of labor is regulated by a meta-

physical entity, which is not the relation of the labor-supply to the general market and demand, but is a result of "the want or suffering of the community." To overcome this entity he would revolutionize trade and production, abolish profit, and base every transaction on its cost in labor, without regard to the results of that labor.

Now, as I understand supply and demand in the market, they are not dead-weights of matter, like a rock crushing my finger; they are forces like the gravitation controlling the rock, and which I must recognize if I would keep my finger whole and escape mental distress. These forces affect laborers and capitalists, producers and consumers alike, and they are the strongest influence in fixing market-prices. In fact, we may consider them the only forces present and active when the selling price is fixed. All other forces must have been transmuted before price can be fixed. It is not easy to comprehend these forces, for Prof. Cairns, while saying[1] "demand and supply are essentially the same phenomena regarded from different points of view, consequently general demand cannot increase or diminish except in constant relation with general supply," yet says also they are "not independent economic forces." Mr. Mill says:[2]

> "Demand and supply—the quantity demanded and the quantity supplied—will be made equal. If unequal at any moment competition equalizes them, and the manner in which this is done is by an adjustment of the value."

Yet every merchant knows that competition is only one of many elements which enter into an "equation" of supply and demand. I dwell on this, not to show the differences of professional economists, but to illustrate the subtlety of these controlling influences of the market-price of labor and commodities. These influences are quite beyond the comprehension of a trades-union as such. We may say a powerful union would employ a leader of great capacity, who would construe these influences properly; but the very process which made him a union-leader would unfit him for a judge of the markets. (A general can lead an army to victory; but generals, as a class, have been poor judges of national policy, in war or peace.) The union-leader may extort an advance of wages through the force of his followers. But this advance in price must be converted into permanent exchange value in order to be of benefit to the laborer. One possible element of this value is the very labor of the unionists themselves while they were striking for the advance; or the advance may have carried the products out of relation to all other values. The only solvents of these delicate problems are the principles of supply and demand I have stated. They must be interpreted by social agents with the highest faculties and the best power of discrimination. If society proves one of these men and finds him trustworthy, it must

[1] "Principles of Political Economy," p. 42.

[2] "Political Economy," vol. i., p. 551, American edition.

keep him and allow him full play. Like tea and wine tasters, they must not be argued with nor forced into unnatural decisions by the power of numbers. If it be said that a unionist can perform this delicate social duty, let us hear what Mr. Thornton [1] says in this regard:

"They" (trades-unions) "tell us plainly what they aspire to is 'control over the destinies of labor;' that they want not merely to be freed from dictation, but to dictate—to be able to arrange the conditions of employment at their own discretion."

Mr. Applegarth, one of the most accomplished unionists, says:

"The business of the employed is to look after their own interests, leaving employers, customers, and the rest of society, to look after theirs and to shift for themselves as they best may."

Firm associations of employers promote the highest economical ends no better when they antagonize the market, or society economically considered. The notion long prevailed in trade and manufactures, that advantages and profits should be secured through monopolies and arbitrary control of the markets. Modern society has abandoned this theory; has forced employers and sellers into a larger view of their own interests through social obligation; and it will compel labor-organizations toward the same end by irresistible social laws. Mr. Thornton admits this principle in another form, for he constantly says the close organizations of laborers are now compelling absolute combinations of the employers to oppose them, and that these latter must surely prevail. Yet he regards the struggle as necessary, and the only means of bringing order and justice out of clashing class antagonisms. However this may be in England, and it is not our business to inquire, in America the principle does not and cannot prevail. European civilization has left but one citadel to the few, in their opposition to the many. Chieftainship, social prestige, money, all pass away from a class if its individual members are not true to its instincts. One fortress remains, where, intrenched by law, the privilege of classes can hold all assailants at bay, and can repair the unthrifty ravages of reckless individuals. Land, the final reservoir of natural advantage, the sure protector of privilege, is, in Europe, practically beyond the reach of the many. In England, the country of greatest abundance, capital ventures itself commercially not below five to ten per cent., while it rests content in land at two per cent. This petty profit shows contrariwise the immense power and value of land. In our country it is practically free; the Government gives a homestead on the open prairie, or, if that be too distant and uncertain, the laborer, riding one hundred miles by rail from a crowded district in New England, can find cheap, fertile lands, with homestead buildings abandoned and decaying. It is impossible for one class to oppress another long, while these doors open freely outward to the

[1] Pp. 193, 194.

great advantages of Nature and land. If, according to Mr. Thornton's theory, employers do not compete for, but combine against labor, or, if they do not compete forcibly enough, Nature does now, and must for centuries to come, open her arms to the sons and daughters of toil. It must be remembered that the thrifty laborer is always a capitalist here. The struggle is not between labor and capital, want and plenty; it is between the employed with a little capital and the employer with more. I throw out of the estimate the improvident and reckless; if socialists or unionists have discovered a method which will give these classes an even chance, they have found a principle which Omnipotence itself has never ventured to put in practice.

If these principles be true, one may ask, Why do we have strikes or discontented laborers in America? I answer, they are the diseases of health; inflammations come from turgid arteries as well as from sluggish veins. Our abounding life has compelled an eager competition among employers. Employers have invariably tended to overproduction, as capitalists know to their cost. Strikes have hardly ever advanced the price of labor; they have never long increased its exchange value, as I indicated above. There is very little communistic sentiment in the United States, but many socialistic theories of a vague sort. That astute public servant, General Butler, would hardly be found uttering such nonsense, if it were not wanted in the socio-political market. The "glittering generality" of equality has partially corrupted the good sense of the citizen; only in part, but the effect is positive. Things are free, they say; why not have a better chance for all? Not through communism; property is both new and old here; it is sacred as a treasure, and dear as a newly-born babe in Anglo-American eyes. Let there be new property; give us all a new chance; the bird of freedom is so 'tarnally strong, why not roast-beef and two dollars a day? The American love of speculation tends in the same direction.

Then there is another principle moving in harmony with this. In great emergencies, when the state or social order is threatened, every American citizen becomes great, and views the State as belonging to all. In petty affairs, and every-day political matters, the average citizen, small capitalist as well as laborer, views the State as belonging to the many considered apart from the few. "The rich have enough; let the poor of the State lean to us," they would say. This blind instinct has entered into strikes and labor-struggles.

The agitators felt that in some way the masses would win, the constable's club would wait on the bayonets, and the militia would sway with the voters for the poor and against the rich; therefore a striker might knock a peaceful laborer on the head with impunity. The common-weal feeling, the American union sentiment as Mr. Wasson puts it, "the sovereignty of rational obligation," must stamp out this atrocious delusion. I regard this issue of fact in the late Fall

River strike as the best and almost the only good principle established there. The municipal and military power promptly restored order and left the trades-unionists their peaceable and natural powers of resistance, all which any association of this sort can legitimately claim.

The fundamental truths cannot be too deeply impressed on both employers and employed. Let no employer busy himself in politics or jurisprudence, about unionist combinations or conspiracies. We have laws enough now, if we will obey and enforce them. If any striker or unionist trespasses on the rights at common law of his employer or brother laborer, punish him with humane haste and compassionate severity. One labor-leader says an employer has no more right to discharge a man than to dungeon him. That is their business individually, and can only be controlled by the larger social and nobler instincts of humanity. If laborers choose to starve rather than work for less wages, or employers choose to rust out their mills rather than take less profits, let them. It is not the business of organized associations to interfere. Not even the State, the greatest of all associations, can control this complication. The issue lies among the great seething forces of the market indicated above; they are both economical and social, any external pressure will only aggravate the difficulty.

There can be only one legitimate power in an American labor association assuming to control the employed; that, in the famous words of Adam Smith, is the power of "higgling the market." On every other side its action is hedged by great social limits which I have indicated rather than stated. This, like friction in mechanics, is a necessary function, but is attainable by other means, and is it worth the social cost involved in associations using all the methods of a despotism? The general rise in wages has been equal, in countries unvisited by trades-unions, to that obtained in England, as Mr. Brassey has shown.

Higgling prices through combination is not a creative force, it is a negative accessory to creative faculties. It involves tremendous waste of social and economical forces. To quote Thornton (pages 344–346):

> "A bricklayer's assistant, who by looking on has learned how to lay bricks as well as his principal, is generally doomed nevertheless to continue a laborer for life." . . . Bricks beyond Lancashire are excluded. "To enforce the exclusion, paid agents are employed; every cart of bricks coming toward Manchester is watched, and, if the contents be found to have come from without the prescribed boundary, the bricklayers at once refuse to work. . . . A master-mason at Ashton obtained some stone ready polished from a quarry near Macclesfield. His men, however, in obedience to club rules, refused to fix it until the polished part had been defaced, and they had polished it again by hand, though not so well as at first! . . . On the importation of worked stone into Barrow, the lodge demanded first that the bases should be worked over again;

secondly, when this was refused as an impossible interference with the architects' design, that as much time as would have been required to rework them should be occupied by the Barrow masons in standing over them."

These are not mere caprices and fancies, they are the certain aberrations which misdirected, arbitrary power must cause.

This power of vagary is even more dangerous politically than it is in the industrial world. The eight-hour league lately attempted to canvass in favor of Randall for Speaker. What business has a labor league, an Odd-Fellows' lodge, or a Methodist church, as such, in the election of an officer of the United States Government? Let them consider Shay's insurrection, the slavery rebellion, and Know-Nothingism, both in its success and its failure.

Politically the genius of America welcomes every individual waif, allows him all liberty of political association or agitation; and he may make social or industrial combinations at will. Let any one of these extra-political associations lift a finger to interfere with a fold of her political garment, and she will crush it under a step heavier than the tread of Roman legions; she will smite it with an arm swifter and mightier than the embodied power of feudal or constitutional monarchies!

I would not deny the right of the individual laborer to "strike" when he is wronged beyond endurance. This inheres in him, like the right of revolution in the citizen—a dangerous power, only to be evoked in dire need, it cannot be formulated socially. As political order binds the citizen, so contract, that mystic sacrament of civilization, must ever hold the laborer fast; it can only be overcome by bitter injustice.

It may be said that trades-unionism, though vicious in direct influence, may enlarge the laborer through indirect social action. We must remember that the laborer here has social opportunities unknown in Europe. The freemasons, militia companies, Patrick's brotherhoods, and Good Templars, all found themselves on broad and benevolent ideas; higgling prices, the one effective force of a trades-union, can hardly equal these ideas in elevating the laborer. Going back to our characteristics of American citizens, it is not to be imagined that we lost all traces of old social groups because we did not represent them in our political organizations. The individual had become sufficiently socialized to be the unit of state, yet he did not lose all historic antecedents. The old groups show their traces in the American as well as in the Italian, German, and Englishman. We have not changed social laws, but given them new elasticity. Water cannot be water unless it intermingles freely with air. Society must refresh itself with new individual units, always moving, always classifying, always mingling unit and group again, like drop and stream, cloud and sea, water and air. Trades-unionism, and all socialism, in so far as it trenches on the State, is a backward step in this American prog-

ress. They clasp rigid fetters on movements which were becoming more supple and elastic. All social organisms are finally parts of the State, that tangible divine power, the right arm of God in his relations with men. There can be no true functions of association which tend to embarrass the free development of the State—the association of associations.

MODERN PHILOSOPHICAL BIOLOGY.

By Dr. E. CAZELLE.

TRANSLATED FROM THE FRENCH BY J. FITZGERALD, A. M.

I.

BIOLOGY, or the science of life, is so new a subject of investigation that its limits are as yet imperfectly ascertained. Metaphysical ideas have too large a place in our conception of its extent. When we ask where biology commences, we are met by the problem of the origin of living things, which very often is solved in accordance rather with preconceived opinions of the system of the universe than with an independent scientific hypothesis. When we would determine its limits, we are met by the problems of cognition, and of the causes determining man's actions; and again usually it is unscientific prejudices that decide whether these problems should be referred to another science, or treated under a subdivision of biology; whether we should range, alongside with phenomena which unquestionably belong to biology, those other phenomena which experience shows us to be closely connected with them, associated with them, and which are in such constant ratio with them in their variations that they appear to derive from them, and from no other source, the conditions of their existence. The indecision as to the limits of biology results principally from the difficulty of giving a strict definition of its subject-matter. Still, in spite of these difficulties, though we cannot say precisely what life is, where its province commences, where it ends, there exists between the two extremes—the inorganic world and the mental world—a very firm ground, imperfectly explored, it is true, but nevertheless belonging to biology alone. The various departments which constitute this domain, though they themselves are not all very clearly defined, are sufficient to give to biology a definite individuality.

Living things present themselves to the observer of Nature as individuals; and it was not long before man began to regard them from another point of view, as forming groups of similar individuals more nearly allied to one another than to individuals in other groups. At first these groups were held to be natural; next it was asked whether, like individuals, they had a history—a beginning and an ending.

This question, as being one that strikes the imagination, naturally arose even before science possessed the means of settling it, and preceded, in the historical order, that thorough study of individuals on which its solution really depends. When men of science had begun to study living things with other purposes than simply that of deriving from them knowledge that would be available for the medical art, and had gained sufficient information for inductive generalizations, they no longer contented themselves with theories of the origin of groups, but sought to reduce to general principles the structure of living bodies—a thing which previously had been considered only from the topographical point of view, and with reference to what was called the use of the parts; and on these general principles they sought to rest a scientific theory of the origin of natural groups.

A man of keen and powerful intellect, who, had he but lived in our time, would have attained the summit of fame, with marvelous acumen anticipated a doctrine which is steadily tending to become a received scientific theory, viz., that the changes which have occurred in Nature are the effects of constant natural laws. Applying this idea to the natural groups of the animal kingdom, he rejected the hypothesis which ascribed to geological catastrophes the destruction of entire faunæ, and the preparation of the earth's surface for a fresh special creation. The transformation of lower organisms into higher he referred to the action of modifications which, though in themselves inconsiderable, became important from repetition and long accumulation, under the influence of forces whose powers he exaggerated. Species and varieties he regarded as artificial groups. According to him the very simplest organisms are derived, by way of spontaneous generation, from naturally-produced plastic substances; then they mutually diverged by imperceptible differences, so as to constitute a linear series, which, but for the gaps caused here and there by lost species, would present to us the aspect of a continuous system. Under favoring circumstances the organs of an animal are modified; a change in the circumstances causes changes in the structure of the individuals belonging to a species, and is the starting-point for the formation of a new species. Crossing, by producing hybrids, still further multiplies the number of species. And species appear to be fixed, simply because the circumstances appear to be similarly fixed during the brief period embraced in our observations. Transformation is the rule, and in the regular course which it runs we can discover no indications of plan or purpose.

The ideas of Lamarck, being but ill supported by positive proofs, were looked on as mere speculations, plausible but doubtful, or even as dreams, unworthy of science; his generalizations were discredited, and even now, when they reappear, backed by a powerful array of facts, but few ever think of giving due honor to their author.

The attempts made at the same period to form generalizations

with respect to the constituent parts of the living individual were more successful. It was not enough to know in a general way that the phenomena observed in living things are in the last resort the same in kind as those which are known as physico-chemical, and that they obey the same laws. Between the phenomena of living things and those of inanimate Nature there existed too wide a chasm; there was no way of passing, deductively, from physico-chemical laws to vital phenomena, and the scientific explanation of organic forms and of functions was of necessity defective. The author of the "Anatomie générale" simply recognized in organs various elements, which he grouped in families, with a view to define, under the general name of tissues, the basis of their structure. In these elements he recognized, independently of their physical and chemical properties, special properties which he justly denominated vital, inasmuch as it is by them that life manifests itself, and which are, properly speaking, the function of these elements. Bichat's generalizations were, doubtless, in his own mind, in opposition to the theory which refers vital phenomena to physico-chemical properties; in point of fact, they have established a relation between functional facts and the general properties of matter. The functional facts of organs are explained by the elementary properties of the tissues; and the latter, though we cannot as yet refer them to physico-chemical properties, are, nevertheless, brought into remarkably close relation with them through our modern ideas of the constitution of organic substances and the principle of the equivalence and transformation of forces.

Still, these relations could not be perceived prior to the discovery of the relations which connect organisms and their tissues with external forces possessed only of physico-chemical properties; and this conception dates from a time long after Bichat's day. We have reason for believing that the part assigned by Lamarck to the action of external circumstances upon organisms first suggested this conception, owing to one of those mysterious operations of the mind which, out of an idea vaguely descried, and even, perhaps, not accepted in the form in which it first presented itself, forms a nucleus around which experience and reasoning group proofs, and which the inventive faculty develops under the form of a doctrine apparently brand-new. The doctrine of the action of "general external modifiers," which Blainville sets forth summarily in his "Cours de Physiologie générale et comparée," by no means possessed, even in his own mind, all the importance it later assumed in science under the name of "doctrine of media," after Auguste Comte had given it so prominent a place in his "Biologie." But, by bringing upon the scene the action of external circumstances upon the sum total of a living organism, and by calling attention to the effects they produce therein, whether as stimulating or reviving the functions, or as suspending the same, Blainville prepared the way for a better interpretation of vital phenomena; and

though he himself, with all this light, did not attain to the truest conception of life, he nevertheless broke ground for those who afterward were to do so.

In more recent times biology has been enriched with an enormous amount of facts for which we are indebted to the labors of naturalists, or even of mere breeders, as also to the labors of anatomists and clinicians, but, above all, to researches in experimental physiology, wherein the application of physical-science methods to the discovery of the laws of vital phenomena has been attended with brilliant success. Amid the extreme complexity of these phenomena it was difficult to perceive the relations of succession which unite them, and to establish positive series. But when men of science refused any longer to content themselves with observing them as they occur spontaneously, and began to vary them by calling in the action of special agents, then modifications were produced, the true causes of which were easily recognized. As in the study of inorganic bodies we learned the laws of their actions and combinations by seeking to find out with the aid of reagents—which are, in fact, special modifiers—the way in which they behave under circumstances that are well known, being fixed beforehand by the observer; so, in the study of living bodies, the introduction of experimentation which alters, according to a plan determined beforehand, the conditions under which the functions of life are to be performed, has enabled us to perceive, with an exactitude previously unknown, the organic properties underlying these functions. Even in embryogeny, a science which once seemed to belong to the domain of simple observation, it has been possible, by way of experimentation, to gain results which shed some light upon teratology. The employment, in observation, of instruments of precision, and in particular of registering apparatus, and of all those processes which suppress causes of error resulting from the personal peculiarities of the observer, gives to the results of research a degree of certitude which renders indisputable facts properly so called, the only question that remains being as to whether these results have been rightly or wrongly interpreted. In addition to an immense amount of unquestionable facts, in addition to a knowledge of the elementary properties of organic tissues and an acquaintance with the special laws which represent the action of these tissues in presence of these modifiers, this general result has followed the conquests of biology, namely, that living bodies are now known to be subject to the self-same laws which govern inorganic bodies, and that, under the hand of the experimenter, the course of things within the tissues is precisely the same as without the tissues; that in the laboratory the elements of living bodies, like those of inanimate things, have their own way of affecting the mind that observes them—that is to say, they possess fixed essential properties which can be determined; and what remains yet to be known is, above all, the mode in which

those organic substances are formed which are the basis of living bodies. The belief which from day to day is gaining confirmation from the labors of physiologists is that so boldly expressed by Claude Bernard, viz., that as the chemist, starting with the knowledge of inorganic bodies, subjects them to his will and creates new bodies, so the physiologist, starting from organic matter, "by imposing upon it special conditions, will be able to produce new physiological modifications and new series of phenomena, thus modifying at will living bodies, and even creating them."

At the same time, by comparing and analyzing the different branches of biology, certain very general laws have been established, particularly in physiology proper, having a bearing upon the development of the individual and the relations of the functions to their organs. We are in possession of a certain number of very broad though purely empiric generalizations on the phenomena upon which the superiority of living things over one another depends. These are, properly speaking, laws of organic Nature.

First, we have the law of the increase of the mass of the organism, in virtue of which each living thing attains its full development only by passing through a series of phases characterized by an augmentation of its mass, and consequently by an augmentation of the quantity of force applicable for its physiological actions, as also by an augmentation of the quantity of functional products.

Then there is the law of the multiplication of parts in proportion as we ascend in the series of living things, this multiplication being determined by an increase of complexity in the organic machine, in virtue of the diversity both of the functions which make their appearance and of the organs which result from this diversity of functions.

Again, we have the law of coördination and subordination of functions and organs, in virtue of which, in proportion as complexity is introduced into the organism and as the functions and organs take on a more special character, certain functions and the organs performing them become dependent on other functions and other organs. Besides, a tie of solidarity is established between all the parts of the living body, so as to guide them toward a common end, the conservation of the individual, while at the same time all of the parts feel the reverberation of the actions to which each is subject.

Next comes the law of adaptation, in virtue of which an organism tends to be so modified as to seem to be specially created to suit the circumstances amid which it exists and the kind of life imposed upon it by them. This law is still, for many thinkers, the basis of ideas of final causes by means of which they strive to explain the structure of living things and the variations observed therein.

Finally, there is the law of heredity, in virtue of which organisms produce new organisms which repeat their type. Heredity is the law of fixity; it expresses the tendency to perpetuate a condition of things

which is itself the result of past environments, and to set it up as a barrier against the influence of new environments.

Descending still deeper, scientific men have sought to explain the constitution of living things, their production, and the existence of the groups into which we find them divided. Hence three theories which have had different fortunes—the cellular theory, the doctrine of spontaneous generation, and transformism.

Schwann, applying to the animal organism Schleiden's discoveries in vegetal organisms, showed that the tissues are formed of primordial, i. e., irreducible, elements, called cells, though often these elements have no cavity and are simply rounded masses. The egg, which is the starting-point of all animal organisms, is at first merely a cell, and develops by producing within itself other cells, which are the primitive materials of the living being. All that the organism is comes ultimately from the cells, which are converted into living tissues. They adhere to one another end to end, and become flattened, or lengthened, or ramified; or they unite and form one common cavity, keeping their walls only at points where they are not in contact, thus forming tubes, or fibres, as, for example, in the histological elements of muscles and nerves.

Some authors have explained the production of cells on the hypothesis of a true spontaneous generation. According to them, cells are organized in a saline solution, the first step being the deposit of a nucleolus, around which there forms an envelope called the nucleus, and finally, at a greater distance, a second envelope, or cell-wall. But no actual experiment has ever been made on the production of cells in this way, and hitherto we have no knowledge of a cell being produced save from a cell. Of this famous theory so much yet remains, viz., that the cell, whatsoever its form and whatever modifications it may have received, is ever the basis of the vital phenomena.

"One only elementary form" (says Virchow) "runs through the whole organic world, remaining ever the same; in vain would we attempt to substitute any thing else for it; there is nothing that can take its place. We have come to regard even the highest formations, whether plant or animal, as being the sum of a larger or smaller number of like or unlike cells. The tree represents a mass put together according to a certain law; each of its parts, leaf or root, trunk or flower, contains cellular elements. The same is true of the animal world. *Each animal represents a sum of vital units*, every one of which has in itself the perfect characters of life. . . . The higher organism, the individual, is always the result of a sort of social organization, of the union of sundry elements combined; it is a mass of individual existences, dependent on each other, though their dependence is such that each element has its own proper activity; so that, whatever impulse or excitation other parts may give to the element, the resulting function nevertheless emanates from the element itself, and is its own."

The question as to how living bodies are produced gave rise, a few years ago, to discussions which have again brought to the surface a

doctrine which was supposed to have been disproved two hundred years since, and which reappeared in the last century only to be assailed with Voltaire's sarcasms. I mean the theory of spontaneous generation, so called—a self-contradictory phrase, by which it was intended to assert that organisms are produced out-and-out without the aid of parents resembling them. While admitting that generation, sexual or asexual, is the mode of reproduction found among animals possessed of complex structure, the partisans of spontaneous generation held, on the strength of their experiments, that certain very low organisms might be developed spontaneously, without specific germs, in infusions of organic substances. But though in this dispute experiment has given no definitive verdict—nor, indeed, was such verdict to be expected—still, all the probabilities are on the side of those who assert the universality of generation by means of germs developed in the parents; and, in the absence of experimental demonstration, we are not without theoretic arguments against the spontaneous generation of the comparatively high organisms developed in infusions. If this doctrine is to be retained, it is not for the purpose of explaining the formation of organisms, a thing well enough explained without it, but in order to account for the production of really primitive living things—i. e., for the appearance of life in a fraction of organic substance, whether this is still possible in our day, or whether it was possible only at a time when, under conditions unknown to us, organic substance originated upon the earth. Thus stated, the question does not depend on experimentation; it becomes a mere exercise of the imagination, and the result is valueless.

Whatever is to be thought of the theory of the beginnings of life, one or more *first* living beings having appeared upon the earth, after the latter had become capable of supporting them, the question arises as to the transition from the primitive simplicity to the enormous degree of variety now existing. Here we have the problem of the origin of species, which is solved by the theory of descent, sometimes denominated transformism. The old conception of living Nature as an infinitely varied assemblage of organisms which faithfully copy certain types, all of whose parts are governed by the law of final causes, in our time gives way, not without a fierce struggle, before a new conception, which represents living Nature as an infinitely varied assemblage of organisms which are ever varying under the influence of external circumstances, while under the influence of heredity they tend to fix in a type the results of previous variations. At one time we have, as in breeding, artificial selection; at another time, as among people who have not yet discovered the laws of breeding, a selection that, though unsystematic, is none the less real; finally in Nature, without human intervention, a selection based simply on the conditions of existence. In natural selection, the action of which is by far the most general and powerful, the fixing of variations results from adaptation

to the existing conditions. This adaptation finds expression in the *survival of the fittest* in the struggle for life; that is to say, those individuals continue to live and reproduce their kind whose structure enables them to undergo changed conditions without succumbing, while others, because they cannot adapt themselves, perish, leaving no posterity, no trace of their having ever existed, save, perhaps, in the geological strata of their epoch. The special advantage which has once insured the survival of an organism, while its congeners which possessed no such advantage perished, is fixed by heredity; it grows under the influence of that same law of survival which insures the upper-hand in the struggle for life to the organisms possessing the advantage in the highest degree; in virtue of the law of the coördination and subordination of parts and functions, it brings about in the whole organism very extensive modifications which insure its fixity; and the sum total of the new characters becomes sufficiently stable to convey to the mind which observes it the impression of the persistence of forms and the existence of types, whereas in fact there exist only changes amid which there remain, in virtue of the law of heredity, traits of resemblance to a common ancestor or stock.

Such are, in brief, the principal laws of biological phenomena, and the chief theories which have been devised for the purpose of assigning to them causes. When, in order to establish or to impugn laws and theories so far-reaching as these, we can have recourse to direct experiment and observation, the mind is satisfied and its certitude reposes on an immovable basis. But when a theory has to do with origins in the remote past, or even in the present, but inaccessible to experiment, our certitude rests on no solid foundation. In the absence of experiment, we have to be content with opinions formed according to the rules of induction and of analogy, and possessing more or less probability. Among views of this sort, those appear to have greatest weight which, in their contexture and in the method of their formation, are most in harmony with those beliefs of which we are most certain; which rest on the same general principles; which, so to speak, are incorporated with our beliefs, so that, were they to succumb to criticism, their fall would compromise the entire system. In other words, they must occupy their own place in a general philosophy, there appearing as so many links in a chain attached, on the one hand, to laws and theories which account for them, and, on the other, to laws and theories which without them cannot be explained.

Could we look for this result from the only general system of philosophy which has existed down to the present day? Having been written at a time when the science of life had for its generalizations only conclusions from Bichat's researches, the hypotheses of Gall, and the results of classification, that portion of the positive philosophy which treats of biology is too far behind the actual state of science to

serve as its guide; yet, owing to the largeness of the views there expressed, Auguste Comte gave to this work a comprehensiveness which enabled it to take in some of the great biological systems elaborated in recent times, and one of his followers has recently declared that the success of these doctrines does not impair the unity of the positive philosophy. It can also be truly said that, if those doctrines were to succumb, the positive philosophy would suffer no loss; and this proves that they have no connection with this philosophy, and that they can receive no support from it. Still, in spite of this serious shortcoming of his philosophy, the services rendered by Auguste Comte are very great. He has given a better definition of life than the one then in vogue; he has perceived that life is a continuous chain of chemical facts, and to this doctrine he has given forcible expression; he has illustrated, by judicious contrast, the relations of the organism to the medium in which it lives; he has stated with great precision the problem of the science of life, which consists in expressing in the least number of laws of the utmost generality the harmony which unites the organism to its medium by vital acts; he has forcibly shown the close correlation which enables us to infer the function from the organ, and *vice versa;* not to speak of a multitude of useful and profound considerations upon the structure of living bodies, on comparative anatomy, and on the physiology of the functions of relation. But it was characteristic of Auguste Comte's philosophy to bind together the parts of its system only by a purely logical tie, and not at all by establishing relations between the phenomena, or by showing interdependency of laws. For him it was enough, in order to assure to biology its place between physico-chemistry and sociology, if on the one hand a knowledge of physical and chemical laws is necessary for the study of biological phenomena, and if the various classes of phenomena pertaining to these sciences really act a part in the production of vital phenomena; and if, on the other hand, a knowledge of the life of relation in its highest aspects, i. e., in the cerebral apparatus, and the elementary intellectual and passional faculties corresponding thereto, is an essential preliminary of the study of sociology. Hence, the biological work of Auguste Comte has not *per se* had any great influence on researches of this kind. The general current of his philosophy has exerted a good influence in so far as it has disinclined men toward theological and metaphysical explications. But we cannot admit that Comte has founded a philosophy of biology fitted to inspire or to guide research. Biological research is still what it was before the positive philosophy became popular; it is still restricted to special points; and, though its spirit is becoming more and more positive, the reason is because in such research the imagination is brought more and more under subjection to the laws of scientific investigation. But, meanwhile, we see no indications of philosophic purpose, no aiming to bring the results obtained under the dominion of a more comprehensive law.

It appears to us that, if a philosophy is to assume this *rôle* and to undertake the guidance of man's thought and action, it must bring forward general principles of such breadth that they will apply to all orders of phenomena, from the simplest to the most complex—a system of laws coördinated by deductive relations, and by its universality expressing all the phenomena of the universe. Whether these general principles are given *a priori*, as the intuitionists hold, or whether they are the abstract expression of an experience invariably and unconditionally repeated, at all events they must be such that from them all our scientific theories may be deduced; they must appear in all our researches as the criterion of the truth of the results, and they must underlie all our anticipations of truth as the guiding principles. Causes, that is to say, the sum of the antecedent phenomena, whose joint action is necessary for the production of the consequent phenomenon, or effect, may be as diverse as you please, nevertheless their relation to their effect will be expressed by the same general law.

A philosophy of biology must reduce under these principles of philosophy all the truths furnished by experience in the various branches of investigation pertaining to that science; must explain them by these principles; must present them to us as necessary, and the contrary results as illogical and unphilosophical, so as to produce a twofold effect, viz., the highest possible harmony in the system of our knowledges, and an ever-strengthening confirmation of the general principles which are their abstract expression. We must demand of it a verdict upon doctrines respecting the constitution of the living individual and its origin and the constitution of the species to which the individual belongs, which verdict shall oblige us to accept these doctrines as corollaries of the same general principles from which the accepted theories of the other abstract sciences are likewise deduced. Finally, we must derive from this philosophy of biology the assurance that the generalizations which it offers to us are grounds upon which we can stand securely in our deductions—of course within the province of biology—respecting man and the human species.

Mr. Herbert Spencer attempts something like this when he rests the laws of biology upon the theory of changes in the course of things, as set forth in his "First Principles." The "Principles of Biology" is the first application of his system of philosophy to a highly-complex order of phenomena.

It will be well to give a sketch of Mr. Spencer's whole system, so that we may better understand the meaning of the abstract terms he employs, and the relations between the general laws on which the system is based. We shall thus be in a position to appreciate the author's application of his system to the more restricted field of biology.

Underlying Spencer's system we find the principle of the persistence of force, "the sole truth which transcends experience," to which

"an ultimate analysis brings us down," and on which "a rational synthesis must build up." From this first principle come as consequences two correlative principles, viz.: uniformity of law, which is simply the persistence of the relations between forces, manifested under identical forms and conditions; and the principle of the equivalence of forces, inductively established within the last twenty years. The researches which resulted in the establishment of this principle rest implicitly on the persistence of force, inasmuch as they measure all the precedent forces, which have disappeared, and all the consequent forces, which have been produced, by the aid of a unit supposed to be constant. If we add two other corollaries, the one relating to the direction of motion in the line of least resistance, the other to the form of motion, which is always rhythmic, we have, with the principles of the continuousness of motion and of the indestructibility of matter (these representing under two correlative forms the principle of the persistence of force), the sum total of the primary truths which serve as a basis for knowledge in general. But these principles, however general, are only analytical truths; though they are essential to a philosophy, they do not constitute a philosophy. They are the laws of the action of forces separately considered. The universal synthesis which is to constitute philosophy must express the total operation accomplished by the coöperation of these factors. The law which shall formulate this synthesis must be a law of the changes in forces under the two phases, matter and motion, by which they are manifested to us: it must be a principle of dynamics holding good both for the whole of the cosmos, and for its every detail. The changes of an object are all produced by new arrangements of the matter constituting it, and by a new distribution of the forces which belong to it. Their necessary direction is given in evolution in virtue of two principles, both of them corollaries of the primary principle of the persistence of force: the law of the instability of the homogeneous and the law of the multiplication of effects.

Every body tends to pass into a more heterogeneous state, because each of the units that constitute it is of necessity differently affected from the others by the combined action of the others upon it; because the resulting difference places each unit in different relations with the incident forces; finally, because these units, owing to their respective positions, cannot all receive the action of an external force in the same direction and with the same intensity. This law, which accounts for the commencement of the changes, accounts also for its continuance.

At the same time a uniform external force, acting on a body, is there dispersed; acting on unlike parts, it breaks up into forces differing in quality and intensity in proportion to the number and diversity of these parts. The same is to be said of each fraction of the force; the process of dispersion goes on increasing, and the result is expressed by the law of the multiplication of effects.

By another law, flowing from the same primary principle, the parts of a whole diverge from one another in proportion to their diversity, and group themselves together in proportion to their resemblances. Motions that are alike in direction or intensity, acting on these parts, drive them in the same direction, and with the same velocity, whence results an *integration* of these parts, while those driven by motions unlike in direction or intensity go in different directions with different velocities, separate from one another, are *disintegrated.* This is the law of segregation, the application of which brings into prominence the heterogeneous character of the products of change, by giving to their heterogeneity a clearer and more definite nature.

Finally, we note another consequence of the persistence of force. Every change in an aggregation of sensible parts is conditioned by opposing forces, the one representing action, the other reaction; the one the tendency to change, the other resistance; their antagonism can end only when equilibrium has been established, by the dissipation of the excess of the one force over the other. A body subject to any disturbance whatever, owing to a modification of its circumstances, tends toward equilibrium with its new circumstances; and, as the different forces acting on it have not the same intensity, those which are weaker soon find their equilibrium, while those which are stronger continue to give motion to the body, and then the latter presents the spectacle of an aggregate whose parts are in an invariable ratio to each other, while the total aggregate is ever changing its relations to external objects. This is *equilibrium mobile,* unstable equilibrium, and it serves as a transition to a more perfect equilibrium, or else to a renewal of the internal movements which have already found equilibrium.

The action of these laws of change of objects and their parts leads to two contrary results, according to the mode of distribution of the forces in action. We have evolution, i. e., change with integration of matter, dissipation of internal motion, increase of the number and diversity of the parts, whenever the external forces are not such as to break the bond which unites them; we have dissolution, continuous or discontinuous, i. e., a change with disaggregation of matter; absorption of motion (which, becoming internal, drives the constituent units with greater velocity) and diminution both of the numbers and of the diversity of the parts, whenever the external forces are sufficiently intense to destroy the cohesion of the aggregate and to restore to its parts their original independence.

The work of Mr. Spencer in his "Biology" consists in referring to these general laws the generalizations obtained in the various parts of the domain of biology, and in discerning those which possess the character of necessity. This course has the twofold advantage of giving to these generalizations greater authority, and of introducing into a coördinated system of philosophy the science whose general-

ized truths they are. The "Principles of Biology" is thus an attempt to explain the phenomena called vital, by general laws common to phenomena of every kind.

[*To be continued.*]

LESSONS IN ELECTRICITY.[1]

HOLIDAY LECTURES AT THE ROYAL INSTITUTION.

By Professor TYNDALL, F.R.S.

I.

SECTION 1. *Introduction.*—Many centuries before Christ, it had been observed that yellow amber (*elektron*) when rubbed possessed the power of attracting light bodies. Thales, the founder of the Ionic philosophy (B. C. 580), imagined the amber to be endowed with a kind of life.

This is the germ out of which has grown the science of *electricity*, which takes its name from the substance in which this power of attraction was first observed.

It will be my aim, during six hours of these Christmas holidays, to make you, to some extent, acquainted with the history, facts, and principles, of this science, and to teach you how to work at it.

The science has two great divisions; the one called "Frictional Electricity," the other "Voltaic Electricity." For the present, our studies will be confined to the first, or older portion of the science, which is called "Frictional Electricity," because in it the electrical power is obtained from the rubbing of bodies together.

Sec. 2. *Historic Notes.*—The attraction of light bodies by rubbed amber was the sum of the world's knowledge of electricity for more than 2,000 years. In 1600 Dr. Gilbert, physician to Queen Elizabeth, whose attention had been previously directed with great success to magnetism, vastly expanded the domain of electricity. He showed that not only amber, but various spars, gems, fossils, stones, glasses, and resins, exhibited when rubbed the same power as amber.

Robert Boyle (1675) proved that a suspended piece of rubbed amber, which attracted other bodies to itself, was in turn attracted by a body brought near it. He also observed the *light* of electricity, a diamond, with which he experimented, being found to emit light when rubbed in the dark.

Boyle imagined that the electrified body threw out an invisible, glutinous substance, which laid hold of light bodies, and, returning to the source from which it emanated, carried them along with it.

[1] A course of six lectures, with simple experiments in frictional electricity, before juvenile audiences during the Christmas holidays.

Otto von Guericke, Burgomaster of Magdeburg, contemporary of Boyle, and inventor of the air-pump, intensified the electric power previously obtained. He devised what may be called the first electrical machine, which was a ball of sulphur, about the size of a child's head. Turned by a handle and rubbed by the dry hand, the sulphur-sphere emitted light in the dark.

Von Guericke also noticed that a feather, having been first attracted toward his sulphur globe, was afterward repelled, and kept at a distance from it, until, having touched another body, it was again attracted. He also heard the hissing of the "electric fire," and observed that a body, when brought near his excited sphere, became electrical and capable of being attracted.

The members of the Academy del Cimento examined various substances electrically. They proved smoke to be attracted, but not flame, which, they found, deprived an electrified body of its power.

They also proved liquids to be sensible to the electric attraction, showing that when rubbed amber was held over the surface of a liquid, a little eminence was formed, from which the liquid was finally discharged against the amber.

Sir Isaac Newton, by rubbing a flat glass, caused light bodies to jump between it and a table. He also noticed the influence of the rubber in electric excitation. His gown, for example, was found to be much more effective than a napkin. Newton imagined that the excited body emitted an elastic fluid which penetrated glass.

Dr. Wall (1708) experimented with large, elongated pieces of amber. He found wool to be the best rubber of amber. "A prodigious number of little cracklings" was produced by the friction, every one of them being accompanied by a flash of light. "This light and crackling," says Dr. Wall, "seem in some degree to represent thunder and lightning."[1] This is the first published allusion to thunder and lightning in connection with electricity.

Stephen Gray (1729) also observed the electric brush, snappings, and sparks. He made the prophetic remark, that "though these effects are at present only minute, it is probable that in time there may be found out a way to collect a greater quantity of the electric fire, and, consequently, to increase the force of that power which by several of those experiments, if we are permitted to compare great things with small, seems to be of the same nature with that of thunder and lightning."[2]

Sec. 3. *The Art of Experiment.*—We have thus broken ground with a few historic notes, intended to show the gradual growth of electrical science. Our next step must be to get some knowledge of the facts referred to, and to learn how they may be produced and extended. The art of producing and extending such facts, and of inquiring into them by proper instruments, is the *art of experiment.*

[1] "Philosophical Transactions," 1708, p. 69. [2] Ibid., vol. xxxix., p. 24.

It is an art of extreme importance, for by its means we can, as it were, converse with Nature, asking her questions and receiving from her replies.

It was the neglect of experiment, and of the reasoning based upon it, which kept the knowledge of the ancient world confined to the attraction of amber for more than 2,000 years.

Skill in the art of experimenting does not come of itself, it is only to be acquired by labor. When you first take a billiard-cue in your hand, your strokes are awkward and ill-directed. When you learn to dance, your first movements are neither graceful nor pleasant. By *practice* alone, you learn to dance and to play. This also is the only way of learning the art of experiment. You must not, therefore, be daunted by your clumsiness at first; you must overcome it, and acquire skill in the art *by repetition*.

By so doing you will come into direct contact with natural truth —you will think and reason not on what has been said to you in books, but on what has been said to you by Nature. Thought springing from this source has a vitality not derivable from mere book-knowledge.

SEC. 4. *Materials for Experiment.*—At this stage of our labors we are to provide ourselves with the following materials:

a. Some sticks of sealing-wax.

b. Two pieces of gutta-percha tubing, about eighteen inches long and three-quarters of an inch outside diameter.

c. Two or three glass tubes, about eighteen inches long and three-quarters of an inch wide, closed at one end, and not too thin, lest they should break in your hand and cut it.

d. Two or three pieces of clean flannel, capable of being folded into pads of two or three layers, about eight or ten inches square.

e. A couple of pads, composed of three or four layers of silk, about eight or ten inches square.

f. A board about eighteen inches square, and a piece of India-rubber.

g. Some very narrow silk ribbon, and a wire loop, like that shown in Fig. 1, in which sticks of sealing-wax, tubes of gutta-percha, rods of glass, or a walking-stick, may be suspended. I choose a narrow ribbon because it is convenient to have a suspending cord that will neither twist nor untwist of itself.

FIG. 1.

I usually employ a loop with the two ends, which are here shown free, soldered together. The loop would thus be unbroken. But you may not be skilled in the art of soldering, and I therefore choose the free loop, which is very easily constructed.

For the purpose of suspension an arrangement resembling a towel-horse, with a single horizontal rail, will be found convenient.

h. A straw, *I I'*, Fig. 2, delicately supported on the point of a sewing-needle *N*, inserted in a stick of sealing-wax *A*, attached below to a little circular plate of tin. In Fig. 8 the straw is shown on a

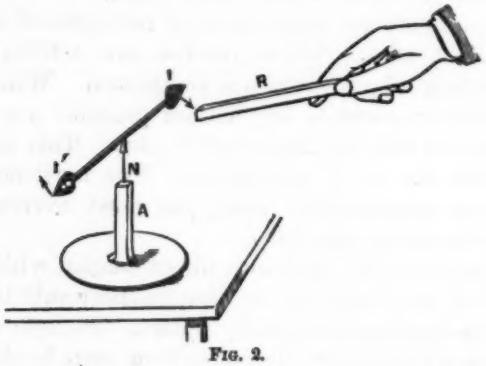

FIG. 2.

larger scale, and separate from its needle. The short bit of straw in the middle, which serves as a cap, is stuck on by sealing-wax.

i. The name of "amalgam" is given to a mixture of mercury with other metals. Experience has shown that the efficacy of a silk rubber is vastly increased when it is smeared over with an amalgam formed of one part by weight of tin, two of zinc, and six of mercury. A little lard is to be first smeared on the silk, and the amalgam is to be applied to the lard. The amalgam, if hard, must be pounded or bruised with a pestle or a hammer until it is soft. You can purchase sixpennyworth of it at a philosophical-instrument maker's. It is to be added to your materials.

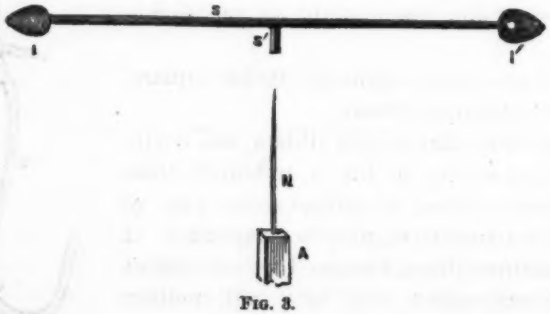

FIG. 3.

k. I should like to make these pages suitable for boys without much pocket-money, and therefore aim at economy in my list of materials. But provide by all means, if you can, a fox's brush, such as those usually employed in dusting furniture.

SEC. 5. *Electric Attractions.*—Place your sealing-wax, gutta-percha

tubing, and flannel and silk rubbers before a fire, to insure their dryness. Be specially careful to make your glass tubes and silk rubbers not only warm, but hot. Pass the dried flannel briskly once or twice over a stick of sealing-wax or over a gutta-percha tube. A very small amount of friction will excite the power of attracting the suspended straw, as shown in Fig. 2. Repeat the experiment several times and cause the straw to follow the attracting body round and round. Do the same with a glass tube rubbed with silk.

I lay particular stress on the heating of the glass tube, because glass has the power, which it exercises, of condensing upon its surface, into a liquid film, the aqueous vapor of the surrounding air. This film must be removed.

I would also insist on practice, in order to render you expert. You will, therefore, attract bran, scraps of paper, gold-leaf, soap-bubbles, and other light bodies, by rubbed glass, sealing-wax, and gutta-percha. Faraday was fond of making empty egg-shells, hoops of paper, and other light objects, roll after his excited tubes.

It is only when the electric power is very weak that you require your delicately-suspended straw. With the sticks, tubes, and rubbers here mentioned, even heavy bodies, when properly suspended, may be attracted. Place, for instance, a common walking-stick in the wire loop attached to the narrow ribbon, Fig. 1, and let it swing horizontally. The glass, rubbed with its silk, or the sealing-wax, or gutta-percha, rubbed with its flannel, will pull the stick quite round.

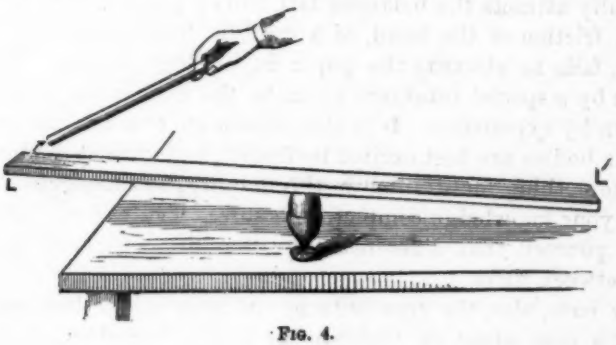

Fig. 4.

Abandon the wire loop ; place an egg in an egg-cup, and balance a long lath upon the egg, as shown in Fig. 4. The lath, though it may be almost a plank, will obediently follow the rubbed glass, gutta-percha, or sealing-wax.

Nothing can be simpler than this lath and egg arrangement, and hardly any thing could be more impressive. The more you work with it, the better you will like it.

Pass an ebonite comb through the hair. In dry weather it produces a crackling noise; but its action upon the lath may be made

plain in any weather. It is rendered electrical by friction against the hair, and with it you can pull the lath quite round.

If you moisten the hair with oil, the comb will still be excited and exert attraction; but, if you moisten it with water, the excitement ceases; a comb passed through wetted hair has no power over the lath.

After its passage through dry or oiled hair, balance the comb itself upon the egg; it is attracted by the lath. You thus prove the attraction to be *mutual:* the comb attracts the lath, and the lath attracts the comb. Suspend your rubbed glass, rubbed gutta-percha, and rubbed sealing-wax in your wire loop. They are all just as much attracted by the lath as the lath was attracted by them. This is an extension of Boyle's experiment with the suspended amber.

How it is that the unelectrified lath attracts, and is attracted by the excited glass, sealing-wax, and gutta-percha, we shall learn by-and-by.

A very striking illustration of electric attraction may be obtained with the board and India-rubber mentioned in our list of materials. Place the board before the fire and make it *hot;* heat also a sheet of foolscap paper and place it on the board. There is no attraction between them. Pass the India-rubber briskly over the paper. It now clings firmly to the board. Tear it away, and hold it at arm's length, for it will move to your body if it can. Bring it near a door or wall, it will cling tenaciously to either. The electrified paper also powerfully attracts the balanced lath from a great distance.

The friction of the hand, of a cambric handkerchief, or of wash-leather, fails to electrify the paper in any high degree. It requires friction by a special substance to make the excitement strong. This we learn by experience. It is also experience that has taught us that resinous bodies are best excited by flannel, and vitreous bodies by silk.

Take nothing for granted in this inquiry, and neglect no effort to render your knowledge complete and sure. Try various rubbers, and satisfy yourself that differences like that first observed by Newton exist between them.

Lay bare, also, the true influence of heat in our last experiment. Spread a cold sheet of foolscap on a cold board—on a table, for example. If the air be not very dry, rubbing, even with the India-rubber, will not make them cling together. But is it because they were *hot* that they attracted each other in the first instance? No, for you may heat your board by plunging it into boiling water, and your paper by holding it in a cloud of steam. Thus heated they cannot be made to cling together. The heat really acts by expelling the moisture. Cold weather, if it be only dry, is highly favorable to electric excitation. During the late frost the whisking of the hand over silk or flannel, or over a cat's back, would have rendered it electrical.

The experiment of the Florentine academicians, whereby they proved the electric attraction of a liquid, is pretty, and worthy of repetition. Fill a very small watch-glass with oil, until the liquid forms a round curved surface, rising a little over the rim of the glass. A strongly excited glass tube, held over the oil, raises not one eminence only, but several, each of which finally discharges a shower of drops against the attracting glass.

Cause the excited glass tube to pass close by your face, without touching it. You feel, like Hauksbee, as if a cobweb were drawn over the face. You also sometimes smell a peculiar odor, due to a substance developed by the electricity, and called ozone.

Long ere this, while rubbing your tubes, you will have heard the "hissing" and "crackling" so often referred to by the earlier electricians; and, if you have rubbed your glass tube briskly in the dark, you will have seen what they called the "electric fire." Using, instead of a tube, a tall glass jar, rendered hot, a good warm rubber, and vigorous friction, the streams of electric fire are very surprising in the dark.

SEC. 6. *Discovery of Conduction and Insulation.*—Here I must again refer to that most meritorious philosopher, Stephen Gray. In 1729, he experimented with a glass tube stopped by a cork. When the tube was rubbed, the cork attracted light bodies. Gray states that he was "much surprised" at this, and he "concluded that there was certainly an attractive virtue communicated to the cork." This was the starting-point of our knowledge of electric conduction.

A fir-stick four inches long, stuck into the cork, was also found by Gray to attract light bodies. He made his sticks longer, but still found a power of attraction at their ends. He then passed on to packthread and wire. Hanging a thread from the top window of a house, so that the lower end nearly touched the ground, and twisting the upper end of the thread round his glass tube, on briskly rubbing the tube, light bodies were attracted by the lower end of the thread.

But Gray's most remarkable experiment was this: He suspended a long hempen line horizontally by loops of packthread, but failed to transmit through it the electric power. He then suspended it by loops of silk and succeeded in sending the "attractive virtue" through 765 feet of thread. He at first thought the silk was effectual because it was thin; but, on replacing a broken loop by a still thinner wire, he obtained no action. Finally, he came to the conclusion that his loops were effectual, not because they were thin, but because they were *silk*. This was the starting-point of our knowledge of insulation.

It is interesting to notice the devotion of some men of science to their work. Dr. Wells finished his beautiful essay on "Dew" when he was on the brink of the grave. Stephen Gray was so near dying,

when his last experiments were made, that he was unable to write out an account of them. On his death-bed, and indeed the very day before his death, his description of them was taken from his lips by Dr. Mortimer, secretary of the Royal Society.

One word of definition will be useful here. Some substances, as proved by Stephen Gray, possess in a very high degree the power of permitting electricity to pass through them; other substances stop the passage of the electricity. Bodies of the first class are called *conductors;* bodies of the second class are called *insulators.*

We cannot do better than repeat here the experiments of Gray. Push a cork into the open end of your glass tube; rub the tube, carrying the friction up to the end holding the cork. The cork will attract the balanced lath, shown in Fig. 4, with which you have already worked so much.

But the excited glass is here so near the end of the cork that you may not feel certain that the observed attraction is that of the cork. You can, however, prove that the cork attracts by its action upon light bodies which cling to it. Stick a pen-holder into the cork, and rub the glass tube as before. The free end of the holder will attract the lath. Stick a deal rod three or four feet long into the cork, even its free end will attract the lath when the glass tube is excited. In this way, you prove to demonstration that the electric power is conveyed along the rod.

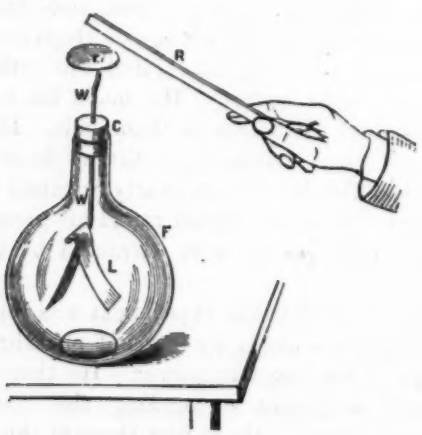

FIG. 5.

SEC. 7. *Further Inquiries on Conduction and Insulation.*—A little addition to our apparatus will now be desirable. You can buy a book of "Dutch metal" for fourpence, and a globular flask like that shown in Fig. 5 for sixpence, or at the most a shilling. Find a cork, *C*, which fits the flask; pass a wire, *W*, through the cork, and bend it near one end at a right angle. Stick by sealing-wax upon the other end of the wire a little plate of tin or sheet-zinc, *T*, about two inches

in diameter. Attach, also, by means of wax to the bent arm, which ought to be about three-quarters of an inch long, two strips, *I*, of the Dutch metal about three inches long and from half an inch to three-quarters of an inch wide. The strips will hang down face to face, in contact with each other. In all cases you must be careful so to use your wax as not to interrupt the metallic connection of the various parts of your apparatus, which we will name an *electroscope*. Gold-leaf, instead of Dutch metal, is usually employed for electroscopes. I recommend the "metal" because it is less frail, and will stand rougher usage.

See that your globular flask is dry and free from dust. Bring your rubbed sealing-wax, *R*, or your rubbed glass, *near* the little plate of tin, the leaves of Dutch metal open out; withdraw the excited body, the leaves fall together. We shall inquire into the cause of this action immediately. Practise the approach and withdrawal for a little time. Now draw your rubbed sealing-wax or glass along the edge of the tin plate, *T*. The leaves diverge, and after the sealing-wax or glass is withdrawn they remain divergent. In the first experiment you communicated no electricity to the electroscope; in the second experiment you did. At present I will only ask you to take the opening out of the leaves as a proof that electricity has been communicated to them.

And now we are ready for Gray's experiments in a form different from his. Connect the end of a long wire with the tin plate of the electroscope; coil the other end round your glass tube. Rub the tube briskly, carrying the friction close to the coiled wire. A single stroke of your rubber, if skillfully given, will cause the leaves to diverge. The electricity has obviously passed through the wire to the electroscope.

Substitute for the wire a string of common twine, rub briskly, and you will cause the leaves to diverge; but there is a notable difference as regards the promptness of the divergence. You soon satisfy yourself that the electricity passes with greater facility through the wire than through the string. Substitute for the twine a string of silk. No matter how vigorously you rub you can now produce no divergence. The electricity cannot get through the silk at all.[1]

Mr. Cottrell, who has been recently working very hard for you and me, has devised an electroscope which we shall frequently employ in our lessons. *M*, Fig. 6, is a little plate of metal, or of wood covered with tin-foil, supported on a rod of glass or of sealing-wax. *N* is another plate of Dutch metal paper, separated about an inch from *M*. *N I* is a long straw (broken off in the figure), and *A A'* is

[1] It is hardly necessary to point out the meaning of Gray's experiment where he found that, with loops of wire or of packthread, he could not send the electricity from end to end of his suspended string. Obviously the electricity escaped in each of these cases through the conducting support to the earth.

a pivot formed by a sewing-needle, and supported on a bent strip of metal, as shown in the figure. By weighting the straw with a little wire near *N*, you so balance it that the plate *N* shall be just lifted away from *M*. The wire *w*, which may be 100 feet long, proceeds from *M* to your glass tube, round which it is coiled. A single vigorous stroke of the tube by the rubber sends electricity along *w* to *M*;

Fig. 6.

N is attracted downward, the other end of the long straw being lifted through a considerable distance. In subsequent figures you will see the complete straw-index, and its modes of application.

A few experiments with either of these instruments will enable you to classify bodies as conductors, semi-conductors, and insulators. Here is a list of a few of each, which, however, differ much among themselves:

Conductors.

The common metals.	Solutions of salts.
Well-burned charcoal.	Rain-water.
Concentrated acids.	Linen.

Living vegetables and animals.

Semi-conductors.

Alcohol and ether.	Marble.
Dry wood.	Paper.

Straw.

Insulators.

Fatty oils.	Silk.
Chalk.	Glass.
India-rubber.	Wax.
Dry paper.	Sulphur.
Hair.	Shellac.

This is the place to demonstrate, in a manner never to be forgotten, the influence of moisture. Assure yourself that your dry silk string insulates. Wet it throughout, and squeeze it a little, so that the water from it may not trickle over your glass tube. Coil it round the tube as before, and excite the tube. The leaves of the electroscope immediately diverge. The *water* is here the conductor. The influence of moisture was first demonstrated by Du Fay (1733 to

1737), who succeeded in sending electricity through 1,256 feet of moist packthread.

A little reflection will enable you to vary these experiments indefinitely. Rub your excited sealing-wax or glass against the tin plate of your electroscope, and cause the leaves to diverge. Touch the plate with any one of the conductors mentioned in the list; the electroscope is immediately discharged. Touch it with a semi-conductor; the leaves fall as before, but less promptly. Touch the plate finally with an insulator; the electricity cannot pass, and the leaves remain unchanged.

NATURAL EUTHANASIA.[1]

By B. W. RICHARDSON, M. D., F.R.S.

BY the strict law of Nature a man should die as unconscious of his death as of his birth.

Subjected at birth to what would be, in the after-conscious state, an ordeal to which the most cruel of deaths were not possibly more severe, he sleeps through the process, and only upon the subsequent awakening feels the impressions, painful or pleasant, of the world into which he is delivered. In this instance the perfect law is fulfilled, because the carrying of it out is retained by Nature herself: human free-will and the caprice that springs from it have no influence.

By the hand of Nature death were equally a painless portion. The cycle of life completed, the living being sleeps into death when Nature has her way.

This purely painless process, this descent by oblivious trance into oblivion, this natural physical death, is the true euthanasia; and it is the duty of those we call physicians to secure for man such good health as shall bear him in activity and happiness onward in his course to this goal. For euthanasia, though it be open to every one born of every race, is not to be had by any save through obedience to those laws which it is the mission of the physician to learn, to teach, and to enforce. Euthanasia is the sequel of health, the happy death engrafted on the perfect life.

When the physician has taught the world how this benign process of Nature may be secured, and the world has accepted the lesson, death itself will be practically banished; it will be divested equally of fear, of sorrow, of suffering. It will come as a sleep.

If you ask what proof there is of the possibility of such a consummation, I point to our knowledge of the natural phenomena of one

[1] From "Diseases of Modern Life," by Dr. B. W. Richardson, now in press of D. Appleton & Co.

form of dissolution revealed to us even now in perfect, though exceptional, illustration. We have all seen Nature, in rare instances, vindicating herself despite the social opposition to her, and showing how tenderly, how soothingly, how like a mother with her foot on the cradle, she would, if she were permitted, rock us all gently out of the world; how, if the free-will with which she has armed us were brought into accord with her designs, she would give us the riches, the beauties, the wonders of the universe for our portion so long as we could receive and enjoy them; and at last would gently withdraw us from them, sense by sense, with such imperception that the pain of the withdrawal would be unfelt and indeed unknown.

Ten times in my own observation I remember witnessing, with attentive mind, these phenomena of natural euthanasia. Without pain, anger, or sorrow, the intellectual faculties of the fated man lose their brightness. Ambition ceases or sinks into desire for repose. Ideas of time, of space, of duty, lingeringly pass away. To sleep and not to dream is the pressing, and, step by step, still pressing need; until at length it whiles away nearly all the hours. The awakenings are short and shorter; painless, careless, happy awakenings to the hum of a busy world, to the merry sounds of children at play, to the sounds of voices offering aid; to the effort of talking on simple topics and recalling events that have dwelt longest on the memory; and then again the overpowering sleep. Thus on and on, until, at length, the intellectual nature is lost, the instinctive and merely animal functions, now no longer required to sustain the higher faculties, in their turn succumb and fall into the inertia.

This is death by Nature, and when mankind has learned the truth, when the time shall come—as come it will—that "there shall be no more an infant of days, nor an old man who hath not filled his days," this act of death, now, as a rule, so dreaded because so premature, shall, arriving only at its appointed hour, suggest no terror, inflict no agony.

The sharpness of death removed from those who die, the poignancy of grief would be almost equally removed from those who survive, were natural euthanasia the prevailing fact. Our sensibilities are governed by the observance of natural law and the breach of it. It is only when Nature is vehemently interrupted that we either wonder or weep. Thus the old Greeks, fathers of true mirth, who looked on prolonged grief as an offense, and attached the word madness to melancholy, even they were so far imbued with sorrow when the child or youth died, that they bore the lifeless body to the pyre in the break of the morning, lest the sun should behold so sad a sight as the young dead; while we, who court rather than seek to dismiss melancholy, who find poetry and piety in melancholic reverie, and who indulge too often in what, after a time, becomes the luxury of woe, experience a gradation of suffering as we witness the work of death. For the

loss of the child and the youth we mourn in the perfect purity of sorrow; for the loss of the man in his activity, we feel grief mingled with selfish regret that so much that was useful has ceased to be. In the loss of the aged, in their days of second childishness and mere oblivion, we sympathize for something that has passed away, and for a moment recall events saddening to the memory; but how soon this consoling thought succeeds and conquers—that the race of the life that has gone was run, and that for its own sake the dispensation of its removal was most merciful and most wise!

To the rule of natural death there are a few exceptions. Unswerving in her great purposes for the universal good, Nature has imposed on the world of life her storms, earthquakes, lightnings, and all those sublime manifestations of her supreme power which, in the infant days of the universe, cowed the boldest and implanted in the human heart fears and superstitions which in hereditary progression have passed down even to the present generations. Thus she has exposed us all to accidents of premature death, but, with infinite wisdom, and as if to tell us that her design is to provide for these inevitable calamities, she has given a preponderance of number at birth to those of her children who by reason of masculine strength and courage shall have most frequently to face her elements of destruction. Further, she has provided that death by her, by accidental collision with herself, shall, from its very velocity, be freed of pain. For pain is a product of time. To experience pain the impression producing it must be transmitted from the injured part of the living body to the conscious centre, must be received at the conscious centre, and must be recognized by the mind as a reception; the last act being in truth the conscious act. In the great majority of deaths from natural accidents there is not sufficient time for the accomplishment of these progressive steps by which the consciousness is reached. The unconsciousness of existence is the first and last fact inflicted upon the stricken organism: the destruction is so mighty that the sense of it is not revealed.

The duration of time intended by Nature to extend between the birth of the individual and his natural euthanasia is undetermined, except in an approximative degree. From the first, the steady, stealthy attraction of the earth is ever telling upon the living body. Some force liberated from the body during life enables it, by self-controlled resistance, to overcome its own weight. For a given part of its cycle the force produced is so efficient that the body grows as well as moves by its agency against weight; but this special stage is limited to an extreme, say of thirty years. There is, then, another period, limited probably also to thirty years, during which the living structure in its full development maintains its resistance to its weight. Finally, there comes a time when this resistance begins to fail, so that the earth, which never for a moment loses her grasp, commences and continues to prevail, and after a struggle, extended from twenty

to thirty years, conquers, bringing the exhausted organism, which has daily approached nearer and nearer to her dead self, into her dead bosom.

Why the excess of power developed during growth or ascent of life should be limited as to time; why the power that maintains the developed body on the level plain should be limited as to time; why the power should decline so that the earth should be allowed to prevail and bring descent of life, are problems as yet unsolved. We call the force that resists the earth vital. We say it resists death, we speak of it as stronger in the young than in the old; but we know nothing more of it really, from a physical point of view, than that while it exists it opposes terrestrial weight sufficiently to enable the body to move with freedom on the surface of the earth.

These facts we accept as ultimate facts. To say that the animal is at birth endowed with some reserved force, something over and above what it obtains from food and air, would seem a reasonable conclusion; but we have no proofs that it is true, save that the young resist better than the old. We must, therefore, rest content with our knowledge in its simple form, gathering from it the lesson that death, a part of the scheme of life, is ordained upon a natural term of life, is beneficently planned, "is rounded with a sleep."

SKETCH OF HERBERT SPENCER.

HERBERT SPENCER was born in Derby, April 27, 1820. He comes of a race of pedagogues—his father, grandfather, and uncles, having followed the profession of teaching. He has written a book upon education, which some people think "theoretical;" but it was a product of experience, for he was himself subjected to much the same method as that he lays down in his work.

The father of Mr. Spencer was a gentleman of fine culture, of engaging manners, and enlightened views which he carried into practice as a teacher. He was strongly disinclined to the prevailing method of imparting knowledge and loading the memory with book acquisitions. He believed that true mental development can only come through self-instruction, and he constantly encouraged his pupils to find things out for themselves. He held it to be of great importance to foster independence and originality of thought. He hence aimed to arouse feelings of interest, curiosity, and love of inquiry in the minds of the young, and then leave them to solve their own problems. One of the objects he constantly sought to attain was to quicken and give scope to the constructive and inventive faculties. He was an excellent mathematician, but in dealing with this subject

he sought to secure objects not usually recognized in the method of this study. He prepared for the use of beginners a little manual entitled "Inventional Geometry,"[1] consisting of questions and problems designed to familiarize the pupil with geometrical conceptions, and to exercise his inventive capacity in actual and accurate constructions with the use of simple instruments.

It was in this discreet way, never crowding or cramming, but kindling his interest and leaving him much to himself, that Mr. Spencer conducted the education of his son.

When Herbert was three years of age, his father's health having broken down, he was compelled to give up his school, and removed to Nottingham. He here entered into the manufacture of lace by machinery, which was just then the rage.

Herbert was the only surviving child, and his health was so delicate that his parents had little hope of raising him. As a lad his health was not strong, although he was not ill; his constitution being well balanced but not hardy. His father, fearing that he would give way under strain, did not press him to study. Three years were spent at Nottingham, in which the boy attended, for a short time, a common day-school kept by a mistress.

When Herbert was between six and seven the family returned to Derby, but Mr. Spencer did not resume his school; he took to private teaching. The lad did not read until he was seven. The first book to which he was attracted was "Sanford and Merton." When, afterward, he went to school, he was very inattentive and idle, having a repugnance to lesson-learning, and never reciting a lesson correctly that was learned by rote. He was, however, leniently dealt with, his father probably directing that he should not be urged. During boyhood he was greatly given to playing games, fishing, birds-nesting, country rambles, gathering wild fruits and mushrooms—all Saturday afternoons being turned to such purposes. Apart from school-studies, his father early led him into drawing, especially from objects. During this same period he encouraged him to keep insects through their transformations, and for years the finding and rearing of caterpillars, the catching and preserving of winged insects were constant and enjoyed occupations. He was also incited to make drawings of these insects. He rarely made friends of bigger boys, being intolerant of any thing like bullying. But his father mentions the fact in one of his letters that the younger boys were very fond of him; implying, perhaps, that while he would not be imposed upon by his elders, he did not bully his juniors. The latter part of his school-days at Derby was passed at a school set up by an uncle who, also having rational ideas of teaching, carried out his father's views. Among some dozen or so of boys he was characterized as backward in things requiring memory and recitation, but as in advance of the rest in in-

[1] Now in the press of D. Appleton & Co.

telligence. Drawing from objects was here continued. They had some experimental lessons in mechanics, and Herbert took to reading a good deal; Rollin's "Ancient History" and many miscellaneous books being gone through. He found a very varied literature in his father's house. Mr. Spencer, Sr., was Secretary of the Derby Philosophical Society, and also member of a Methodist book-committee. Besides many works of different kinds, there came various periodicals and magazines—the *Lancet*, the medical quarterlies, *Athenæum*, *Chambers's Journal*, volumes of travel, and occasionally graver works. All these he habitually looked into as a boy, picking up medical, mechanical, and various information. Mr. Spencer and his brothers, when they were together, habitually discussed all kinds of questions, political, ethical, religious, and scientific. All were liberal and independent thinkers—radicals when radicalism was unpopular. Both Mr. and Mrs. Spencer were brought up Methodists, but, during his boyhood, the father acquired so strong a repugnance toward the priestliness of the Methodist organization, that he early ceased to attend their services, and went to Quaker meeting—never adopting their peculiarities, but approving their unsacerdotal system. As his mother continued a Methodist, it resulted that on Sunday he went with his father in the morning, and with his mother in the evening. The enforced learning of hymns, and reading of chapters, at this time, produced a lasting repugnance to Scriptural language.

Mr. Spencer encouraged his son in all kinds of little constructive operations, as carpentering, the making of his own fishing-tackle, etc. Readiness in manipulation was thus cultivated. During this period, Mr. Spencer from time to time had at the house assemblies of his private pupils to witness electrical, mechanical, and air-pump experiments. In these Herbert always assisted, becoming thus familiar with the facts, explanations, and practical manipulations. At the same time he made chemical experiments. He is reported as being much in disgrace as a disobedient boy, always more or less in hot water, which led to desponding anticipations of his future.

At thirteen (1833) he was sent to his uncle, a clergyman, with whom he remained three years. This uncle, the Rev. Thomas Spencer, Rector of Hinton, was a cultivated scholar, who graduated with honors at Cambridge. He was a man of great liberality, advanced in his political views, broad in his theology, and the first clergyman of the Established Church to take a public and prominent part in the movement for the repeal of the corn-laws; having written and published extensively upon the subject. He will be remembered by some as having made a tour through this country some twenty-five years ago, delivering occasional lectures. His uncle was anxious that Herbert should prepare for the university, but he was disinclined to this, and the question was a matter of controversy between them. His uncle, however, lived to acknowledge that Herbert probably took the

right view of the matter. Yet his prescribed studies were those which constitute the usual preparation for a university course. Latin and Greek, which had been taken up at Derby, though but to little purpose, were resumed at Hinton, but they were pursued without interest, and no satisfactory progress was made in them. But in mathematics the pupil made rapid advancement, being the equal or superior of fellow-students several years his seniors, who were studying with him. Geometry, trigonometry, algebra, mechanics, and the beginning of Newton's "Principia," were gone through. Though his memory was never a good one for details, yet it is noted that principles were habitually so seized as to remain. The tendency to independent exploration was shown in the spontaneous making of problems, and finding out new demonstrations. The discipline to which Herbert was subjected was here more decided than it had been at home. Yet during his stay at Hinton there were various accusations of disobedience which led to temporary disgrace.

At sixteen (1836) Herbert returned home, and one year was passed in miscellaneous but not very persistent study. He went through perspective with his father, on the principle of independent discovery; the successive problems being put in such order that he was enabled to find out the solutions himself. There was evidently a natural readiness here, as during this year he hit upon a curious theorem in descriptive geometry, which was afterward published with the demonstration in the *Civil Engineer's and Architect's Journal.*

At midsummer, 1837, after being a year at home, he had three months' experience in teaching, taking the place of assistant in the school to which he had first gone as a boy. His father had always been anxious that he should follow the profession of teacher, the dignity of which he estimated highly. This wish was strengthened by the success which he had in this trial, as he evinced a strong natural faculty for exposition, and the capacity of leading pupils to feel an interest in their lessons by the use of copious and correct illustrations.

In the autumn of that year, young Spencer was offered an engagement under Mr. Charles Fox (afterward Sir Charles Fox), a civil-engineer who had been a pupil of his father, and who subsequently became widely known as the builder of the Great Exhibition building of 1850. He was at that time resident engineer on the London & Birmingham Railway, then in process of construction. Here, partly in making surveys and drawings, he passed nearly a year, still carrying on his mathematical studies, and showing in his letters that inventions and improvements were much in his thoughts. In the autumn of 1838 he was recommended to Captain Moorsum, engineer of the Birmingham & Gloucester Railway. He took this place, and some eighteen months were passed in making engineers' drawings, and other railway works, with some contributions to the *Civil Engineer's Journal*, describing improved methods and constructions. Toward

the end of this period he became for a time Captain Moorsum's engineering secretary, and during this time he devised the little instrument which he called the velocimeter, and described in the *Civil Engineer's Journal.* It was for the purpose of calculating, by mechanical means, the speeds of locomotive engines from given fractional distances and times, which otherwise required much trouble in estimating the velocity. Then followed a period of some six months occupied in out-door works, partly in superintending the completion of constructions, and partly in testing the performances of engines.

During this period he was led, by collecting fossils, into the study of geology, and read Sir Charles Lyell's "Principles," then recently published. The noteworthy fact respecting this is, that in it the doctrine of Lamarck respecting the development of species is there set forth, combated and rejected. Mr. Spencer cannot say whether he was before familiar with this doctrine, but he remembers that Lyell's arguments failed to disprove it to him, and he became, thereafter, a firm believer in the general idea that all organized beings had arisen by development (1839). He had so profound a belief in natural causation, in general so strong a tendency to see a unity of processes in things, that an hypothesis of this kind, which suggested that the genesis of organisms had arisen from physical actions, was one that he was prepared to accept as congruous with the system of things known by experience. Such a notion as that of miracle, utterly inharmonious with the ideas of cause and law and order which had become ingrained in him, was inadmissible, and hence the only alternative view presented itself to his mind as obviously necessary. Nothing ever afterward shook this belief. There naturally went along with this a gradual dropping of the current theology, although Mr. Spencer cannot say when it began or when it ended. The conception of the natural genesis of things gradually replaced the conception of the supernatural genesis, and belief in the prevailing creed gradually faded away.

In April, 1841, having declined the offer of an engineering appointment, Mr. Spencer returned home, intending to carry further his mathematical studies. Very little came of this intention, however, and some two years were spent at home in a miscellaneous and seemingly futile manner. Botany occupied his attention for some months. He made a botanical press and an herbarium. He practised drawing to some extent, and made pencil-portraits of various friends. Phrenology, of which he did not at that time see the fallacies, occupied some attention. All the time, however, he had in progress one or other scheme of invention. Improvements in watch-making, machines for making type by compression of the metal instead of casting, a printing-press of a new form, the application of the electrotype for engraving, afterward known as the glyptograph, occupied his attention. The great flood in Derby, in 1842, caused by the sudden overflow of a tributary of the Derwent, having occurred, Mr. Spencer wrote

a detailed report upon it with proposals for remedy to the town council, which was printed by that body. The summer of that year was spent in a visit at Hinton, and while there he modeled a bust of his uncle, having during the previous year given some attention to that art. He also there commenced contributing to the *Nonconformist* a series of letters on the proper sphere of government. These were completed in the autumn. Shortly after there was commenced in England a movement called the complete-suffrage agitation, which arose out of a pamphlet published by the editor of the *Nonconformist*, Mr. Miall. In this agitation Mr. Spencer took an active part, becoming the local secretary for Derby, and he was afterward delegate to a conference at Birmingham, where a futile attempt was made to cooperate with the Chartists. In the spring of 1843 he went to London, with the vague idea of getting some literary occupation, and while there he made an engineering engagement, which lasted a few months till the work was complete. Returning then to Derby, he was again occupied chiefly with inventions. The railway mania, which was rising in 1844, drew him again to engineering, and he was for some months in charge of a London office, where he had at one time about sixty men under him. That winter and the subsequent spring were spent before parliamentary committees. But the lines in which he was interested failed to be chartered, and he then had much experience in legal proceedings, helping the engineer to recover his charges.

During 1846 and the beginning of 1847 he was occupied with inventions, and took out a patent for a sawing and planing machine, but, the friend who joined him in it going to India, the business dropped through. During these years he contributed papers to the *Philosophical Magazine* and to the *Zoöist*, in one of which he propounded a view respecting the nature of sympathy, which he afterward found that Adam Smith had previously proposed. In 1848 he commenced writing "Social Statics." In the autumn of that year he was engaged as the sub-editor of the *Economist*, and during 1849 and 1850 while occupying that post he completed the volume, his first considerable work, "Social Statics."

It is unnecessary to sketch here the intellectual labors of Mr. Spencer, as that has been already done with some degree of fullness in our pages.[1]

Much solicitude regarding the disturbed health of Mr. Spencer has been expressed by many who are interested in the progress of his work, and exaggerated rumors have been circulated respecting it. As we have said, his constitution was never robust, but it was sound in the earlier portions of his life. His health gave way when thirty-five years old, from intense application in writing "The Principles of Psychology," published in 1855. Since that time he has been incapable of steady mental application, and has been compelled frequently

[1] *See* POPULAR SCIENCE MONTHLY for November, 1874.

to suspend labor entirely for varying intervals to recover his working condition. When he entered upon his philosophical undertaking in 1860—laying out twenty years of original work—his health was so insecure that many thought the project foolhardy, and that it would prove fatal to him. But, forced by painful experience to economize his energies, he has become an adept in the art of taking care of himself; so that, instead of breaking down, his condition has perhaps improved with the progress of his work. He would probably never have been able to *write* the volumes of his philosophy, but in 1859 he adopted the expedient of dictation to an amanuensis, and attributes his power of going on to the immense economy and advantages of this practice. He has latterly not been so well as usual, for, though turning off a large amount of work on "The Principles of Sociology," and also carrying along the "Descriptive Sociology," both of which works are well advanced, he has yet been interrupted by more prolonged intervals of inability to labor. He has, besides, had to spend a great deal of his force in attention to business, which is not a very exhilarating occupation, as he has now sunk nearly $20,000 in the preparation and publication of his "Descriptive Sociology." He has, besides, had to maintain a burdensome correspondence, which growing at last intolerable, he has lately sought relief by lithographing the following form of a letter, which will explain itself:

"Mr. Herbert Spencer regrets that he must take measures for diminishing the amount of his correspondence.

"Being prevented by his state of health from writing more than a short time daily, he makes but slow progress with the work he has undertaken, and this slow progress is made slower by the absorption of his time in answering those who write to him. Letters inviting him to join committees, to attend meetings, or otherwise to further some public object; letters requesting interviews and autographs; letters asking opinions and explanations—these, together with presentation copies of books that have to be acknowledged, entail hindrances which, small as they may be individually, are collectively very serious—very serious, at least, to one whose hours of work are so narrowly limited.

"As these hindrances increase, Mr. Spencer finds himself compelled to do something to prevent them. After long hesitation, he has reluctantly decided to confine himself absolutely to the task which he is endeavoring to accomplish—to cut himself off from all engagements that are likely to occupy any attention, however slight, and to decline all correspondence not involved by his immediate work.

"To explain the absence of a special reply to each communication, he has adopted the expedient of lithographing this general reply; and he hopes that the reason given will sufficiently excuse him for not answering, in a more direct way, the letter of Mr. ——.

"37 Queen's Gardens, Bayswater, W."

CORRESPONDENCE.

"THE CONFLICT OF THE AGES."

To the Editor of the Popular Science Monthly.

DEAR SIR: I have read this morning, with great pleasure, the article by President White, in the February number of your magazine; and am free to express gratification at seeing the extracts from my Vanderbilt University Address placed in such "goodlie companie."

But you must permit me to express my surprise at the tone and some of the statements which you make with regard to the two articles, and to the important subject which they discuss. You say that you print my argument because it is "on the other side of the question," and you would "not be accused of partiality or injustice to opposite views." This is utterly unaccountable to me. President White and myself are in perfect accord in our articles so far as "the conflict" is concerned, so much so that, if we had had a conference previous to the preparation of our two addresses, we could scarcely have selected modes of treatment different from those we adopted. We should possibly have changed the order of the printing, and let his follow mine. Mine is a statement of doctrine, and his the proof. He has written almost nothing in his article which I might not have written if I had had his ability. He brings a masterly analysis and great wealth of learning to prove what I have asserted, and nothing in his article seems to stand against any thing in mine. We hold the same thesis, and sometimes express our ideas *ipsissimis verbis*. We both agree, if I have not utterly misapprehended President White, that religious men make mistakes, and scientific men make mistakes, but there is no conflict between *true* religion and *true* science, the warfare of science being with something other than religion. The first words of mine which you quote are these: "The *recent* cry of the 'Conflict of Religion and Science' is *fallacious*, and *mischievous* to the interests of both science and religion" (p. 434). President White, in the first sentence of his thesis says, "In all *modern* history, interference with science in the *supposed interest* of religion . . . has resulted in the *direst evils both to religion and to science*, and invariably" (p. 385). There we agree, and each undertakes to show the same thing in his own way. President White, in the second sentence of his thesis, says, "All untrammeled scientific investigation, no matter how dangerous to religion *some* of its stages may have *seemed, for the time*, to be, has invariably resulted in the highest good of religion and of science." In divers places in my article the same is set forth and maintained. On page 444 I say, "If, for instance, a conflict should come between geology and theology, and geology should be beaten, it will be *so much the better for religion*; and, if geology should beat theology, *still so much the better for religion*," etc. In the next sentence, "geologists, psychologists, and, theologists, *must all* ULTIMATELY promote the cause of religion, because they *must* confirm one another's truths and explode one another's errors," etc. And, next sentence, "He (the religious man) knows and feels that it would be as irreligious in him to reject any truth found in Nature as it would be for another to reject any truth found in the Bible."

Now, on this showing, my dear sir, I think that in a review of the two articles you should be ready to admit that Dr. White and I are *not* on "opposite" sides. We are advocates for the same client, speaking from different briefs but promoting the same cause.

But I am sorry to find that, while I thoroughly agree with Dr. White, *you* do not. You consider the conflict to be "natural," "inevitable," "wholesome." Dr. White teaches that "the idea that there is a necessary antagonism between science and religion" is "*the most unfortunate of all ideas*" (p. 403). You oppose Dr. White more than you do me, for my moderate statement is, that it is "fallacious" and "mischievous."

I would fain "labor" with you, as some of our religious brethren say. It grieves me that you hold that an antagonism between *loving obedience to God*—Religion, and *intelligent study of God's works*—Science, is "natural," "inevitable," "wholesome." If that be true it would seem to follow that the more religious a man is the less scientific he can be, or, what is worse, that the more scientific a man the less religious can he be! Really you cannot mean what your statements logically convey. You cannot mean to teach that, the more wicked a man is, the better he is prepared for scientific investigation. But do not your words mean that?

To prove that there is a necessary conflict you call attention to "the attitude of mind of the great mass of devout and sincerely religious people toward the more advanced conclusions and scientific men of the present day." Who can tell what attitude that is? Each man knows his circle of acquaintances; and here is my testimony: All "the devout and sincerely religious people" with whom I am acquainted accept *all* the "conclusions" of science so far as they know them. Some of them go further, and accept even the hypotheses and guesses of the most poetic and superstitious of "the scientific men of the day." The body of devout religious people, however, it is fair to add, do not accept all the guesses. All that can be reasonably asked of the religious people is that they shall accept as *scientific* "*conclusions*" only those teachings of science in regard to which there is no controversy *among scientific men*. A case cannot be called "concluded" while the argument is going on in court. The rotundity of the earth, the heliocentric theory, Kepler's three laws, are "concluded." No scientific man of repute expresses the slightest doubt of those, and the attitude of religious people toward them is one of thorough acceptance and genuine faith. There are some religious people who are evolutionists. Some are not. But the scientific men, "*as such*," are just as much divided, so that that question cannot be called concluded.

As to the attitude of religious people toward advanced scientific men, it would be difficult to determine, because it would be difficult to determine who are the "advanced" scientific men. Whenever they settle that among themselves, your question will really have great importance; but, if a clique should cry up one man as a burning and shining light in science, while the French Academy should be reported to have rejected him when nominated for membership, on the ground that *he is not scientific*, need religious people have any attitude toward him at all?

But that there is no hostile attitude toward scientific men is shown by the fact that *any* scientific lecturer of ability may come from Europe to America, and the devout and religious people of the country will go in throngs to hear him, and pay liberally for the privilege.

You close your article by expressing the opinion that a "desirable consummation" to "reach" would be "the entire indifference of religious people, *as such*, to the results of scientific inquiry." This is amazing. How can they be? Religious people who are not scientific know very well, having had their attention freshly called thereto by Dr. White, the great benefits conferred on religion by the progress of science, which, as he admirably says, has "given to religion great new foundations, great new ennobling conceptions, a great new revelation of the might of God." Religious people owe too much to science, while science owes almost every thing to religious people, to allow them to become entirely indifferent, and give up science wholly to irreligious men.

One thing let us agree on before we part. Nothing is advanced and no one is profited if religious men write and speak as though no man could be scientific and at the same time religious; nor is any thing profited if men professing to be scientific talk of religious people patronizingly, as if they were simpletons. Can you not say "Amen" to that, and shake hands with

Very respectfully and truly yours,

CHARLES F. DEEMS.

CHURCH OF THE STRANGERS,
NEW YORK, *January* 27, 1876.

EDITOR'S TABLE.

HISTORY AND THE CENTENNIAL.

THERE are symptoms of a revival of the study of history, or of a new impulse to it, as a consequence of the fact that the life of the nation has reached a round hundred years. Histories of the United States are in special order, and histories of the world for common schools are copiously forthcoming. The importance of history is, of course, a foregone conclusion; and the triple importance of the history of one's own country goes for self-evident. This is the wrong year to disturb political superstitions, and we are not going to question the great necessity of reading more about the doings of politicians for the last hundred years than past facilities have made practicable. But we may suggest that it is not an unsuitable time to widen and liberalize somewhat our notions of what history properly is, or should be. That it has hitherto dealt mainly with the superficies of human affairs, with conspicuous surface effects, and with the sayings and doings of men who have been skillful in the art of keeping themselves in the focus of public observation, has come to be a truism. And, when a history of the United States is announced, it is well enough understood that we are to have a new shaking-up of the old materials, with new pictures, but with the usual account of Indians, constitution-making, political administrations, and the wars in which the country has been engaged.

But is not our impending Centennial celebration in Philadelphia calculated to impress upon us the historic interest of quite a different class of things? No doubt there will be collected and placed on show numerous relics and curiosities of purely national import; but these will not constitute the staple attractions of the exhibition. Its supreme interest will consist in the array of products which will be there gathered of the art, science, invention, and skill, of the world. It is these that have been appealed to, to signalize and make memorable the hundredth year of our separate national life. This is the realization of an idea which could hardly have entered into the dreams of the men who figured as "founders of the republic." Their notion of "celebrating" our "Independence" for all time, consisted in making a prodigious noise, by ringing bells, and exploding gunpowder. But now we celebrate this event on a grand scale, by invoking the coöperation of the civilized world in the competitive display of industrial resources, constructions, fabrics, and works of use and beauty, distributed through a hundred departments of classified variety. And, of these multitudinous results of man's inventive and constructive faculty, the great mass will be the products of the past century's experience and progress, of which hardly the germs existed when we set up in politics for ourselves. And they will not be the results of administrative policy or forms of government. In a large sense they will not belong to any nation, but to civilization and humanity. They will be, to no small degree, the achievements of enterprise which politicians of all countries have done their best to hinder and defeat. It is the triumph of our time, that the forces that have brought such vast and benign consequences have overcome all resistance. They represent the growth and power of the pacific and constructive agencies of modern society—the headway that has been made against the political barbarisms of the past. The chief display at the Centennial will symbolize the silent revolutions

of ideas—triumphs achieved by individuals through heroic self-sacrifice, and unwearying labor, in the seclusion of the laboratory, the study, and the workshop. And, as regards popular history, it is now pertinent to ask if it might not be wisely extended over this field of human exploit. The records of inventive, scientific, and social progress might lack something of the tragic excitement that belongs to the chronicles of battles and campaigns, and might be read with less avidity than accounts of cabinet intrigues, partisan strife, and gossiping sketches of men who have got themselves voted into the category of the great; but, for the serious purposes of education, would not histories of the former type be better suited for the wants of an enterprising, practical, self-governing people, than those which are now pressed upon our schools? We need popular histories of the arts and sciences, of inventions and discoveries, of industries and commerce, the development of ideas, the order of social changes, and the working of those deeper forces in human affairs which history has hitherto overlooked, and of which, indeed, mankind has only become fully conscious in recent years. We need them, but the need is probably no measure of the demand for them. If they were written, the chances for their "adoption" would, perhaps, not be very encouraging. But we may indulge the hope that the influence of the Centennial Exhibition will, at any rate, be favorable to the growth of this branch of literature.

RETROSPECTS OF OUR PAST HUNDRED YEARS.

THE reviews that have been published of what has been done in this country in the great departments of thought, during the past century, are not without promise that the mind of the time is moving in the direction desiderated in the preceding article. The *North American Review*, for example, has published a centennial number, devoted entirely to the course of American thought in religion, politics, abstract science, economic science, law, and education, from 1776 to 1876. The papers are able, calm, and philosophic, without a glimpse of the "spread eagle" or trace of the "stump," and their general tone, in fact, is by no means that of jubilation.

Mr. J. L. Diman begins by giving an instructive account of religion in America, and pointing out the leading changes that have taken place, most important of which is the complete separation which has been effected between church and state. He shows how deep was the conviction in our early history that laws for "maintaining public worship, and decently supporting the teachers of religion," are "absolutely necessary for the well-being of society." This view was not the result of ecclesiastical prejudice, but was most strongly advocated by laymen. Chief-Justice Parsons, not a member of a church, in entering upon his official career, expressed his most solemn conviction "of the necessity of a public support of religious institutions;" and, still later, Judge Story maintained the same view. This ground, now generally abandoned by American Protestants, is that still held by the Catholic Church, and gives rise to one of the gravest difficulties of public policy, that in relation to religion and state education.

As regards the growth of sects, it is stated that "a century ago the more important religious bodies (tested by the number of churches) were ranked in the following order: Congregational, Baptist, Church of England, Presbyterian, Lutheran, German Reformed, Dutch Reformed, Roman Catholic. By the census of 1870 they stood: Methodist, Baptist, Presbyterian, Roman Catholic, Christian, Lutheran, Congregational, Protestant Episcopal." The growth of religious organizations has outstripped the growth of population. At the beginning of the Revolution

there were less than 1,950 with a population of 3,500,000, showing a church for every 1,700 souls. There are now more than 72,000, which, with a population of 38,000,000, would show a church for every 529. "In other words, while the population has multiplied elevenfold, the churches have multiplied nearly thirty-seven-fold." The most signal religious fact which the past century presents is stated to be the growth of Methodism. When their first conference met at Baltimore they collected but sixty preachers, and it was reckoned that in the whole country they could muster but twenty more. "By the census of 1870 they were credited with more than 25,000 parish organizations, and a church property of $70,000,000." Notice is taken of the tendency to appreciate a more educated clergy, and of a growing ambition in the matter of church architecture. The general movement, it is said, has led not so much toward the multiplication of sects as toward the formation of compact and powerful religious organizations. But there has been little reciprocal influence among ecclesiastical bodies, and no tendency to theological unity. The general conclusion of the writer is that "a review of our past history should incline us to place a modest estimate on our success;" and "at the close of a century we seem to have made no advance whatever in harmonizing the relations of religious sects among themselves, or in defining their common relation to the civil power. . . . The function of American Christianity has been discharged in a moral and practical, rather than in a scientific and theological development."

Prof. Sumner's sketch of American politics for a hundred years is highly instructive and readable, but on the whole any thing but flattering to the national vanity. The "Ring" and the "Boss" seem to be its latest outcome, and of the latter character it is said, "he is the last and perfect flower of the long development at which hundreds of skillful and crafty men have labored, and into which the American people have put by far the greatest part of their political energy." Whether in politics the course of the nation has been on the whole upward or downward, the writer considers an open question, but comforts us with his individual opinion that we are not degenerating.

Prof. Newcomb, in reviewing the abstract science of the century, discusses with much ability the conditions on which the cultivation of pure science depends, and finds that they are greatly wanting in this country. There is a lack of intimate intercourse among scientific men; of government appreciation of the aid they require in devoting themselves to original research. There is, besides, a kind of national one-sidedness—not merely an absorption in material interests—a kind of faith in practical sagacity and the sufficiency of plain common-sense for all emergencies, which excludes the need of more exact methods of thought, and is inappreciative of the value of refined and remote inquiries that yield no palpable or directly useful results. It is therefore natural "that the development of the higher branches of science in our country should be marked by the same backwardness which characterizes the higher forms of thought in other directions." Prof. Newcomb brings out, in an admirable passage, the complete antagonism between the ideas "which animate the so-called 'practical man' of our country and those which animate the investigator in any field which deserves the name of science or philosophy;" from which it appears that the most potent hindrance to science with us is that adverse state of the general mind which prevents our people from taking interest in it, and of encouraging those who devote themselves to it. He says: "It is strikingly illustrative of the absence of every thing like an effective national pride in science that two generations should have passed without America having

produced any thing to continue the philosophical researches of Franklin. . . . Until Henry commenced his experiments there was not an electrical investigation published in the country, which the present time has any object in remembering."

"We have described and illustrated the generally low state of American science during the first forty years of the present century—a state which may be described as one of general lethargy broken now and then by the activity of some first-class man, which, however, commonly ceased to be directed into purely scientific channels. Since 1840 there has been a great and general increase of activity in some directions, which, from some points of view, would seem to have inaugurated an entirely new state of things, and to promise well for the future. But there are also many features of the case which strongly suggest the backward state of things from which the present condition sprung."

After reviewing a large mass of facts, Prof. Newcomb says: "We must not conclude, from all this, that no interest in science is taken by the American people, but only that that interest does not manifest itself in such a way as to promote scientific research." And his general conclusion is that, "on the whole, we have not been able to present the first century in roseate colors; and, while we can well contemplate the future with hope, we cannot do so with entire confidence."

Prof. Dunbar's delineation of a century of economic science is clear and cogent, but no more flattering than that of his predecessor. He gives an interesting account of the various writings that have been contributed by prominent men to this question, and, although it would at first seem that the practical genius of our people would here find its legitimate field, and that what they loved dearest and thought of most—money, currency, property, trade—they would be the ones to explore to the utmost depths; yet such is far from having been the case. The tracing out of unknown laws and the original discovery of principles are the same in all spheres of phenomena. Prof. Dunbar concludes: "The general result, then, to which, as we believe, a sober examination of the case must lead any candid inquirer, is that the United States have thus far done nothing toward developing the theory of political economy, notwithstanding their vast and immediate interest in its practical applications." He shows how it is that our politicians are interested in bemuddling economical questions, and spreading the notion that nothing is here settled, because the interests are to be manipulated for selfish ends. "In the case of the currency question, then, it appears that the subject, from the first, came before our public men in a form which seemed to make its political bearings too important to be subordinated to any scientific treatment. The same might be said of the tariff discussion, which, apart from its inevitable complication with individual interests, has never failed also to present itself in such sectional or party relations as to make its settlement turn largely upon far other considerations than those of general principles." It is further shown how the great prosperity of the country has blinded men to the injurious influence of economic blunders. "The idea that the management of our resources is of little account so long as we find ourselves sweeping along with the current of growth has for years been the habitual consolation of our public men, if not an article of their faith. That it easily leads to indifference, as to the monitions of economic law, is sufficiently obvious."

Mr. G. T. Bispham treats of the progress of American jurisprudence during the past century. He first considers those deviations from English law which originated in the contrast of physical features between this country and England. That country is a compact,

densely-populated island, with small rivers, forests that are the objects of jealous care, with cheap labor, and high-priced land; contrasting strongly with the extent of this country—its enormous streams, sparse population, cheap lands, imperfect roads, and timber so abundant that it was an impediment to improvement. These differences necessitated marked modifications in American law to adapt it to the physical and geographical peculiarities of the country. Many changes of jurisprudence, of course, grew out of the adoption of a new form of government embodied in a new constitution, which gave a distinctive character, in many features, to the system of American law. It is maintained, also, that general intellectual influences have wrought an advance in American jurisprudence, which is seen in the amelioration of criminal legislation, and in legislation establishing public or state education. It is, moreover, contended that the adoption of written constitutions is an important step of progress which the world owes to the United States; another American step being the codification and simplification of municipal law. The writer finally concludes that "the law in this country has, in the progress of its hundred years of life, become (1) more simple, (2) more humane, and (3) more adaptive;" and he thinks that "the pathway it has pursued is one upon which we can turn our eyes with feelings of no little pride."

Prof. D. C. Gilman sketches the history of American education, regarding it "in the three stages which are commonly known as 'primary,' 'secondary,' and 'superior' instruction." A large amount of historical information is digested, relating to the rise and progress of the primary-school system, the course of legislation upon the subject, the controversies it has involved, and the difficulties that have arisen by the extension of it to the freedmen of the South. The weakest portion of the American system is stated to be that of "secondary" instruction, which is intermediate between the elementary and collegiate schools. The maxim that "our public schools must be cheap enough for the poorest; good enough for the best," indicates an obstacle that has long stood in the way of the organization of higher schools; but within the last twenty years, especially within the cities and large towns, many of these have arisen, and in the West have become the favorite means of securing higher instruction. As regards the "superior" education, it is stated that, at the commencement of the Revolution, there were nine colleges in eight of the thirteen colonies. These establishments have multiplied, until "in 1875 the Commissioner of Education reported the names of 374 institutions, mostly called universities and colleges, which are legally entitled to confer academic degrees, besides independent schools of law, medicine, and theology, of which there are 106, and colleges for women, of which there are 65; so that there are known and recorded 545 degree-giving institutions within the United States.

The general scope of our "superior" education is thus indicated:

> "The typical American college has been a place where a prescribed course of study, largely devoted to Greek, Latin, and mathematics, with a brief introduction to historical, political, and ethical sciences, has continued during four years and led to a bachelor's degree."

Various questions regarding our collegiate system are ably discussed by Prof. Gilman, but he hardly touches the important topic of scientific education. Perhaps this was from lack of space, but, as he is engaged in the organization of a university to be devoted to the higher studies, this subject must have engaged his very serious consideration, and we hope he will favor the public with his views upon it at some suitable time.

LITERARY NOTICES.

THE EMOTIONS AND THE WILL. By ALEXANDER BAIN, LL. D., Professor of Logic in the University of Aberdeen. Pp. 604. Price, $5. New York: D. Appleton & Co.

THE author of this work stands among the very foremost in the school of modern scientific psychology, which has its chief development in Great Britain. His two principal works, "The Senses and Intellect" and "The Emotions and the Will," are widely known as giving the only complete and systematic account of mental phenomena from a modern point of view. As we know nothing of mind, except as an organic manifestation—as physically embodied and working its effects through a complex and wonderful vital machinery—no exposition of it can be regarded as scientific or complete that leaves the material side of the phenomena out of account. We have often insisted upon this, and must continue to do so; for the importance of the truth is only equaled by the inveteracy with which the futile and exhausted metaphysical method is still clung to in the general study of mind. There is hardly a chapter of either of Dr. Bain's books that is not a virtual demonstration of the necessity of including the physical accompaniments of mind in any treatment of it that claims to be scientific in method, and valuable in application. The general adoption of these works as college and high-school text-books would give a new and valuable element to our higher culture. Mental philosophy would then become what it ought to be, a study of human character, and such an analysis and understanding of the constitution of man as would give us a better interpretation than hitherto of his relations to surrounding Nature.

The third edition of "The Emotions and the Will" has been thoroughly revised at every point. Although it may seem a hopeless task to introduce quantitative inquiries involving much precision into psychology, yet, as Dr. Bain remarks, it is essential to the scientific handling of the subject, and he has accordingly given much attention to the problem of degrees of intensity and force in regard to the feelings, and to the extension and improvement of the means adopted in this branch of psychical investigation.

But perhaps the most significant feature of the new edition of this work is its reconstruction with reference to the doctrine of evolution. As the eminent comparative anatomist of Germany, Gegenbauer, reorganized his great biological work so as to bring it into harmony with evolutionary views, and as Sir Charles Lyell recast his "Principles of Geology" so as to base it upon the doctrine of development and descent, Dr. Bain has now done the same thing with his elaborate treatise upon the mind. Herbert Spencer had indeed grounded psychology upon evolution in a remarkable work published twenty years ago; but it was far in advance of the thought of the time, and even progressive psychologists have but slowly come up to his position. Prof. Bain fully recognizes the eminence and authority of Mr. Spencer in this field of psychological investigation.

THE TEACHER'S HANDBOOK FOR THE INSTITUTE AND THE CLASS-ROOM. By WILLIAM F. PHELPS, M. A., Principal of the State Normal School, Winona, Minnesota. Pp. 335. Price, $1.50. New York: A. S. Barnes & Co.

THIS little work by an experienced educator, who is also an enthusiast in his profession, may be regarded as the outcome of the most advanced and perfected methods of instruction in the American school system. It is a text-book for teachers in acquiring the art of their vocation, and aims to familiarize them both with the theoretical principles and the practical processes by which general education should be conducted in schools, under the control of the state. Prof. Phelps is an ardent advocate of state education, and urges it on the usual ground of political necessity in a popular government. And whatever question there may be as to the right or wrong, or the good and bad of this policy, we have entered upon it, and are committed to it, and nothing remains but to meet the responsibilities and discharge the duties that grow out of it. Such a system inevitably results in comprehensive organization. With system in study there comes grada-

tion in schools, and with improvement in methods and results there comes a demand for the special cultivation of teachers, by means of institutes and normal schools.

This complex machinery of education must be thoroughly understood by every efficient teacher in its principles and practical working, and Prof. Phelps's book has been prepared to facilitate this special professional culture. It is written with the warmth of a man who is in earnest, and with the clearness of one who understands his subject. Unsettled questions and difficulties in education are recognized, with judicious suggestions, as in the following passage:

"The question as to what shall be taught in our common schools is yet to receive a definite solution. Next in importance to right methods of teaching ranks the subject-matter of teaching. 'What knowledge is of most worth? What branches are the most useful, first for discipline, and second for use or particular application?' Upon this subject we have no settled policy. As a consequence, many things inferior usurp the place of those of superior worth. The dry details of so-called geography, the abstract definitions, rules, and formulas of grammar, the comparatively valueless signs and symbols of algebraic notation, consume a vast amount of the time that should be devoted to the study of the earth, its climate and productions in their relations to man, and the course of human history; of the English language, as a means of communication, and of the living sciences which lie at the basis of all the arts and industries of life. But it is futile to attempt a revolution in subject-matters while teachers, their attainments, and methods of work, are so inadequate to the public needs. It is idle to talk of the necessity of the elements of physics and chemistry, botany and physiology, natural history and agriculture, so long as we have neither the knowledge nor the skill requisite to their proper treatment. Of what value would these sciences be to the people when mechanically memorized from the printed page, as are most of the subjects now in our common-school curriculum? To be of use, either for discipline or application, they must be properly taught by observation, experiment, and demonstration. In short, their objects must be seen, handled, analyzed, compared, and classified. These practical sciences must be investigated by methods and processes analogous to those by which they have been themselves developed, and thus far perfected. Can our children be expected to grope their way to these natural processes in spite of their teachers? or, must the latter first be made capable of leading the way, inspiring the young by the fullness of their learning, and the skill of their methods? Until our children and youth learn the right use of their own powers, it is in vain to expect that they can master the powers of Nature, or accomplish any other important result."

THE URANIAN AND NEPTUNIAN SYSTEMS, INVESTIGATED WITH THE 26-INCH EQUATORIAL OF THE UNITED STATES NAVAL OBSERVATORY. By SIMON NEWCOMB, LL. D., Professor United States Navy. Washington Observations for 1873. Appendix I. Government Printing-Office, 1875, pp. 72, 4to.

THIS pamphlet, separately printed, contains the first published discussion of work done by the 26-inch Clark refractor of the Naval Observatory.* What this work was, and how great necessity existed for its prosecution, may be gathered from the first two paragraphs of the memoir:

"The remoteness of the two outer planets of our system renders the accurate investigation of their satellites a task of great difficulty. This is strongly evinced by the great discordances between the conclusions respecting the masses of those planets which have been reached by various observers. Thus, in the case of Uranus, Von Asten, the latest investigator, cites a number of determinations of the mass from recent observations, which range between $\frac{1}{17917}$ and $\frac{1}{22026}$ [of the sun's mass], so that the largest result is nearly half as large again as the smallest. Even different results, obtained by the same observer under slightly different circumstances, were surprisingly discordant. The best determination was that of Struve; but even here there was a difference of four per cent. between the results from the two [brighter] satellites. In the case of Neptune, discordances of the same kind showed themselves; Struve's mass being greater than that of Bond by one-third.

"For these and other reasons, when the 26-inch equatorial, with an object-glass nearly perfect in figure, was mounted at the Naval Observatory, the observation of the satellites of the outer planets, with a view of determining not only the elements of their orbits, but more especially the masses of the planets, was made the first great work of the instrument. Entertaining the opinion that, in the present state of astronomy, it was better to do one thing well than many things indifferently, the minor arrangements of the instrument were all made subservient to the end in view, and no other serious work of a dissimilar character was attempted during the continuance of the observations."

It is well known that the two brighter satellites of Uranus, viz., *Oberon* and *Titania*, are quite faint objects even in the large 15-inch telescopes of Harvard College and of Pulkova, but the two interior satellites, *Ariel* and *Umbriel*, are incompara-

bly the faintest and most difficult objects to observe in the solar system. Indeed, it is not wholly certain that they have ever been seen save in the telescopes of Mr. Lassell (their discoverer), Lord Rosse, and by the Washington refractor, although there are several telescopes now mounted both in Europe and in America which are adequate for their observation.

The satellite of Neptune, too, is a very difficult object, and hence it is extremely gratifying to find so many measures of these satellites as Prof. Newcomb has obtained. The telescope was mounted in November, 1873. From that time to April, 1875, there were made:

81	observations of	*Oberon.*
84	"	" *Titania.*
10	"	" *Umbriel.*
8	"	" *Ariel.*
54	"	" *Neptune's satellite.*

It must be remembered that *Neptune* was only observed from July to February, and *Uranus* from January to May.

From a consideration of all the measures of *Uranus's* satellites, the author assigns as the mass of that planet $\frac{1}{22600}$ of the mass of the sun, and he estimates the probable error of the denominator of this fraction at 100, so that we may say that this mass is not *less* than $\frac{1}{22700}$, and not *more* than $\frac{1}{22500}$; that is, the mass is determined within less than $\frac{1}{200}$ part of its value. To understand the nicety of such measurements as have been made, it must be remembered that any error in the measures of the *distance* of the satellite from the planet is shown in the resulting mass of the planet in an amount not proportional to this error directly, but to the *third power* of the error.

The times of revolution of the satellites have been determined with high accuracy by a comparison of Newcomb's observations with those of the elder Herschel—the uncertainty in the period of *Titania* = $8^{days}.705897$, being not more than one second of time, or $\frac{1}{7000000}$ of the whole amount.

From the relative brightness of the satellites of Uranus, Prof. Newcomb concludes that they have masses not more than $\frac{1}{40000}$ of that of Uranus itself, i. e., vastly less than the mass of our own moon.

It is an interesting fact too that the author suspects that the nearest of the satellites of Uranus (*Ariel*) "belongs to that class of satellites of which the brilliancy is variable, and depends on its position in the orbit." With regard to the interesting question as to the number of satellites of Uranus, Prof. Newcomb's testimony is as follows:

"No systematic search for new satellites of this planet was entered upon, partly because the season in which Uranus is in opposition is now an unfavorable one for prosecuting such a search, and partly because the attempt would have absorbed so much of the observer's time and energies as to detract from the excellence of the micrometer-observations. When faint objects, which might have been new satellites, were seen around the planet, their positions relative to the latter were noted; but in no instance was any such object found to accompany the planet. I think I may say, with considerable certainty, that there is no satellite within 2′ of the planet, and outside of Oberon, having one-third the brilliancy of the latter, and therefore that none of Sir William Herschel's supposed outer satellites can have any real existence. The distances of the four known satellites increase in so regular a way that it can hardly be supposed that any others exist between them. Of what may be inside of Ariel, it is impossible to speak with certainty, since, in the state of atmosphere which prevails during our winter, all the satellites would disappear at 10″ distance from the planet.'

The second section of the memoir deals with the Neptunian system. Three principal determinations of the mass of Neptune have been made:

Bond's,	which gives the mass			$\frac{1}{19360}$.
Struve's,	"	"	"	$\frac{1}{19380}$.
Lassell's,	"	"	"	$\frac{1}{19350}$.

From the work of the Washington telescope the mass results $\frac{1}{19360}$, which agrees most remarkably with Bond's previous determination.

No evidence for an elliptic form to the orbits of any of these satellites has been made out: "We are thus led to the remarkable conclusion that the orbits of all the satellites of the two outer planets are less eccentric than those of the planets of our system, and that, so far as observations have yet shown, they may be perfect circles. No trace of a second satellite of Neptune has ever been seen, though several times carefully looked for, under the finest atmospheric conditions, during July, 1874."

We have thus far spoken mainly of the

most interesting results reached in Prof. Newcomb's memoir. It contains besides these a very complete development of the analytical methods required for the discussion of observations of this class, and practical hints as to the manner of making and treating such observations, which are of great importance. It is a gratifying thing to be able so soon to announce important results attained by means of the new telescope at Washington, and to see that so great a scientific trust as this has been administered by competent and faithful hands.

THE SCIENTIFIC MONTHLY. Pp. 55. Toledo, O.: E. H. FITCH, Editor and Proprietor.

THE second number of this magazine has a diversified table of contents. The first article (illustrated) is on "The Swallow-tailed Kite." There are two articles by Prof. Charles Whittlesey; the one on "Rock Inscriptions" in Lorain Co., Ohio, and the other a comparison of the Indian and the Mound-Builder. The titles of the other leading articles are: "Climate and Disease," "The Brain," "The Archippus Butterfly," and "Some Atmospheric Phenomena." Price, $3.00 per year.

THE JOURNAL OF MENTAL AND NERVOUS DISEASE. Chicago: 57 Washington Street. Pp. 175. Subscription, $5 per annum.

THIS quarterly commences with the January number a new series. Its editors are J. S. Jewell, M. D., and H. M. Bannister, M. D., with Drs. W. A. Hammond, S. Weir Mitchell, and E. H. Clarke, as associate editors. This first number of the new series contains Dr. Hammond's address on "The Brain not the Sole Organ of the Mind;" a paper by Dr. R. W. Taylor on "Syphilis of the Nervous System;" "Pathology of Tetanus," by Dr. Bannister; "Pathology of the Sympathetic Nervous System," by Dr. Clark; "Treatment of Inebriates," by Dr. N. S. Davis; and "Cerebral Anæmia," by Dr. T. L. Teed.

SCIENCE BYWAYS. By RICHARD A. PROCTOR. Pp. 438. Philadelphia: Lippincott. Price, $4.00.

UNDER this title Mr. Proctor brings together sixteen essays, originally published in various magazines, on a wide range of topics. Two of these essays have appeared in the MONTHLY, namely, "Finding the Way at Sea," and "Money for Science." The latter subject the author purposes to discuss at greater length in a pamphlet soon to be published. As a popular expositor of science Mr. Proctor stands high, and this volume will be heartily welcomed by the important public to whom the author addresses himself. Among the other subjects treated in the present volume, we may name the following: "Life in Other Worlds," "Comets," "The Sun a Bubble," "The Weather and the Sun," "Rain," "Have we Two Brains?" "Automatic Chess and Card Playing."

THE *American Naturalist* begins the year 1876 with improved form and increased volume; each number now contains 64 pages. The magazine will be less technical than heretofore, and will have some additional departments, devoted to geography and travel, proceedings of scientific societies, etc. The first number issued since the "new departure" opens with a paper by Prof. A. Gray, entitled "Burs in the Borage Family." There is also a paper by Rev. Samuel Lockwood, in his usual lively style, on *Anolis principalis*, the American analogue of the chameleon of the Old World. There are five other leading articles in this first number. The *Naturalist* is now published by Hurd & Houghton, Boston. Subscription price, $4 per annum.

PUBLICATIONS RECEIVED.

Native Races of the Pacific States. By H. H. Bancroft. Vol. V. New York: D. Appleton & Co. Price, $5.50. Pp. 796.

Angola and the River Congo. By J. J. Monteiro. Pp. 366. New York: Macmillan. Price, $2.50.

The Christ of Paul. By George Reber. Pp. 397. New York: Somerby. Price, $2.00.

Magnetism and Electricity. By F. Guthrie. Pp. 364. New York: Putnams. Price, $1.50.

Public Instruction in Minnesota. Pp. 235. St. Paul: *Pioneer Press* print.

The American State. By W. G. Dix. Pp. 187. Boston: Estes & Lauriat. Price, $1.50.

Life Histories of Animals. By A. S. Packard, Jr. Pp. 243. New York: H. Holt & Co. Price, $2.50.

How to build Ships. By a Seaman. Pp. 62. New York: Van Nostrand. Price, 75 cents.

Hayden's Geological Survey of the Territories. Vol. II. Pp. 304, with numerous Plates. Washington: Government Printing-Office.

Water and Water-Supply. By W. H. Corfield. Pp. 145. New York: Van Nostrand. Price, 50 cents.

Principles of Coal-Mining. By J. H. Collins. Pp. 150. New York: Putnams. Price, 75 cents.

Wages and Wants of Science-Workers. By R. A. Proctor. Pp. 118. London: Smith, Elder & Co.

Imports and Exports of the United States. Washington: Government Printing-Office.

Supposed Miracles. By Rev. J. M. Buckley. Pp. 54. New York: Hurd & Houghton. Price, 50 cents.

Circulars of the Education Bureau. Washington: Government Printing-Office.

How to construct a Dairy-Room. By J. Wilkinson. Pp. 26. Baltimore: J. Wilkinson. Price, 25 cents.

The Yucca-Borer. By C. V. Riley. Pp. 23. St. Louis: R. P. Studley.

Bulletin of the National Museum. Also Bulletin of the Geological and Geographical Survey of the Territories. Washington: Government Printing-Office.

Proceedings of the Cincinnati Society of Natural History. Pp. 12.

Through and Through the Tropics. By Frank Vincent, Jr. Pp. 304. New York: Harper & Brothers.

Early Literature of Chemistry. By H. C. Bolton. Vol. I. Pp. 10. Philadelphia: Collins, printer.

First Annual Report of the Johns Hopkins University. Pp. 34. Baltimore: Boyle & Son, printers.

American Leporidæ. By J. A. Allen. Pp. 8.

Pharmacy in Germany. By F. Hoffmann. Pp. 12. Philadelphia: Merrihew & Son, printers.

MISCELLANY.

Exhibition of Scientific Apparatus.—There will be opened next April, at the South Kensington Crystal Palace, London, a universal exposition of scientific instruments. This exposition will continue for six months. Its object is to bring together as large a number as possible of scientific instruments possessing an historic interest, for instance, Tycho Brahe's astrolabes, Galileo's telescopes, Lavoisier's balances, Franklin's lightning-rods, the remnants of Charles's balloons, Giffard's injector, Leon Foucault's pendulum and gyroscope, etc. All the cost of transportation will be borne by the Department of Arts and Sciences. The home committee consists of one hundred scientific men, with the lord-chancellor. It is stated in the *Moniteur Industriel Belge* that an invitation has been sent to every civilized nation to take a part in the exhibition.

Fossil Coniferæ.—Prof. J. W. Dawson, in the *American Journal of Science* for October, invites correspondence from geologists who have examined the remains of coniferous trees in the carboniferous rocks of the United States. Hitherto, he says, little attention seems to have been given in this country to these remains of ancient vegetation. In Nova Scotia, several species are known, and are to some extent characteristic of definite horizons. In the carboniferous sandstones of the United States such remains seem to be frequent, but Dr. Dawson has seen no detailed account of them. The subject, he adds, is deserving of the attention of microscopists in the coal districts, as there can be little doubt that several interesting species remain to be discovered; for instance, the curious *dictyoxylon* of Williamson, found also in Nova Scotia, would probably reward patient slicing of trunks showing structure. The De-

vonian has treasures of the same kind. In the United States it has already afforded *Dadoxylon Halli* from New York, and *D. Newberryi* from Ohio, besides the curious *Ormoxylon Erianum*. No doubt other species remain to be discovered, especially in the Upper and Middle Devonian.

Habits of Hermit-Crabs.—In the *American Journal of Science* for October, Mr. A. Agassiz records some observations on the hermit-crab. He raised a number of these animals from a very early stage in their life till they reached the condition in which they require the protection of a shell. A number of shells, some empty, others occupied by living mollusks, were now placed in the glass dish with the young crabs. The empty shells were at once taken possession of. The crabs which were not so fortunate as to obtain untenanted shells remained riding about upon the mouth of their future dwelling, and on the death of the tenant, which generally occurred soon after in captivity, commenced at once to tear out the animal, and, having eaten him, proceeded to take his place within the shell. The question arises, How did the crab acquire the faculty of performing this act? Not by imitation, in this instance at least. Possibly by inheritance; Mr. Agassiz, however, is inclined to regard the act as purely mechanical—rendered necessary by the conditions of the young hermit-crab. "When the moult has taken place, which brings them to the stage at which they need a shell, we find important changes in the two hind-pairs of feet, now changed to shorter feet capable of propelling the crab in and out of the shell; we find, also, that all the abdominal appendages except those of the last joint are lost, but the great distinction between this stage and the one preceding it is the curling of the abdomen; its rings are now quite indistinct, and the test covering it is reduced to a mere film, so that the whole abdomen becomes of course very sensitive. It is, therefore, natural that the young crab should seek some shelter for this exposed portion of his body, and, from what I have observed, any cavity will answer the purpose; one of the young crabs having established himself most comfortably in the anterior part of the cast skin of a small isopod, which seemed to satisfy him as well as a shell, there being several empty shells at his disposal."

Position of Science in English Schools.—In their sixth report the British Commission on Scientific Instruction relate their observations on the state of science-teaching in public and endowed schools. The present state of scientific instruction in the upper schools is declared to be extremely unsatisfactory. The returns furnished by the public schools show that, even where science is taught, from one to two hours' work per week may be regarded, with very few exceptions, as the usual time allotted to it in such classes as receive scientific instruction at all. Moreover, the instruction in science is generally confined to certain classes in the school. Of the 128 minor endowed schools from which returns were received, only 18 devote as much as four hours per week to the teaching of science, and only 13 have a laboratory of any kind. The commissioners hold that science is a complementary and not an exceptional part of education; that it should not be regarded merely as a by-work, whether to satisfy the natural curiosity of most, or to develop the peculiar tastes of a few; and that, if need be, Greek should yield place to it in the universal curriculum.

Liebig's Influence on German Science.—Dr. Thudichum recently delivered a lecture before the London Society of Arts, on "Liebig's Discoveries, and their Influence on the Advancement of Arts, Manufactures, and Commerce." Toward the end of the lecture he indicates, as follows, one of the indirect effects of Liebig's researches: "The Prussian and other German universities now teach students of science and agriculture in great numbers, where thirty years ago law and theology filled the auditories. In that time the number of students of Protestant theology has decreased in Prussia from upward of 2,000 to less than 800, and in Hesse-Darmstadt from 50 to 13. One-sixth of all parsonages are without incumbents, because there is no one to receive the appointments. Such is the beginning of the great reformation which is now being wrought in human affairs by science."

NOTES.

THE Smithsonian Institution is making a collection to illustrate, at the Centennial Exhibition, the resources of the United States as derived from the animal kingdom. This collection will embrace specimens of the animals of the United States which are hunted or collected for economical purposes; the products derived from the various species; also the apparatus or devices employed by hunters, trappers, sportsmen, and others.

THE artesian well at the Collier White-Lead Works, St. Louis, Missouri, has attained a depth of over 700 feet, nearly all of which depth has been through limestone. The drift is but slightly above the encrinitic limestone, and has passed through but little of either sandstone or chert. The boring commenced in the lower Archimedean limestone.—*Scientific American.*

A PROFITABLE industry in the vicinity of Cape May, New Jersey, is the mining of ancient cedar-logs in the mire of the swamps. In these swamps, says the Monmouth *Democrat*, are buried enormous trees at a depth of from three to ten feet. The logs lie one across another, and there is abundant evidence that they are the growth of successive forests. The mode of searching for the logs is as follows: An iron rod is thrust into the soft mud, over which, often, the water lies. After several soundings the workman is able to tell how the tree lies, which is its root-end, and how thick it is. He then contrives to get a chip from the tree, and so determines at once whether it is worth the labor of mining. A pit is now dug, into which the water soon flows, filling it up. The tree is then cut across with a saw at regular intervals, each section floating to the surface. A layer of such trees is found covered by another layer and these again by another, and even a third, while living trees may still be growing over all.

A MARBLE scroll has been set up in Westminster Abbey, bearing an inscription in honor of Jeremiah Horrocks. Among the labors of his short life the inscription signalizes the following: Discovery of the long inequality in the mean motion of Jupiter and Saturn; demonstration of the elliptical form of the moon's orbit; determination of the motion of the lunar apse; prediction, from his own observations, of the transit of Venus in 1639.

FIFTY years ago the great auk was found in large numbers on the Funk Islands, off the coast of Newfoundland, but soon after became extinct. The story of its extermination is briefly told as follows in the *American Naturalist:* The birds were hunted for their feathers by the Newfoundland fishermen, who would row round them in small boats and drive them ashore (the auks being unable to fly) into pounds. The birds were immersed in scalding water to remove the feathers, and their bodies were used as fuel for boiling the water. It is doubtful if the species *Alca impennis* now exists anywhere about the islands of Newfoundland or Labrador.

IN the year ending November 30, 1875, the Royal Society of London lost 29 Fellows by death. Of these, fourteen were between 70 and 80 years of age, six between 80 and 90, and three between 90 and 95. Of all the Fellows now living, Sir Edward Sabine has been for the longest time a member of the Society; he was elected in 1818.

IN a paper by John Willis Clarke, published in the *Contemporary Review*, it is stated that the Confederate cruisers Alabama and Shenandoah, by interfering with the American seal-fishery, preserved the breed of the fur-seal in the Southern Ocean from complete extinction.

AT a recent meeting of the Buffalo Society of Natural Science, Profs. Grote and Pitt announced the discovery of a marine fucoid in the water-line group. The specimen is one of the best preserved of the kind yet discovered. It shows no close affinity to any known fucoidal remains.

LIEUTENANT CAMERON reached Loanda in November, having made the journey from Zanzibar, including a two months' survey of Lake Tanganyika, in two years and eight months.

THE California Academy of Sciences is now absolute owner of the property given to it by Mr. Lick. Its present income, in the shape of rents, is about $4,000, and this sum is destined to increase rapidly. Its members number five hundred, including seventy-five life members. The donations to the museum during the year 1875 were numerous and valuable. At the last annual meeting the vice-president, Mr. Edwards, suggested the adoption of some plan of distributing the members in sections of Geology, Botany, Entomology, etc., each section to assemble weekly and pass upon papers which, if approved, would be presented at the fortnightly meetings of the Academy.

THE remains of a mastodon have been discovered at Lisle, Broome County, New York. The portions so far found are a piece of tusk 7 feet 3 inches long, and another piece 2 feet long; a humerus 38 inches long; one rib 49 inches long, and 21 shorter ribs; the atlas, 10 by 17 inches, and several of the caudal vertebræ.

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Caroline Herschel.

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